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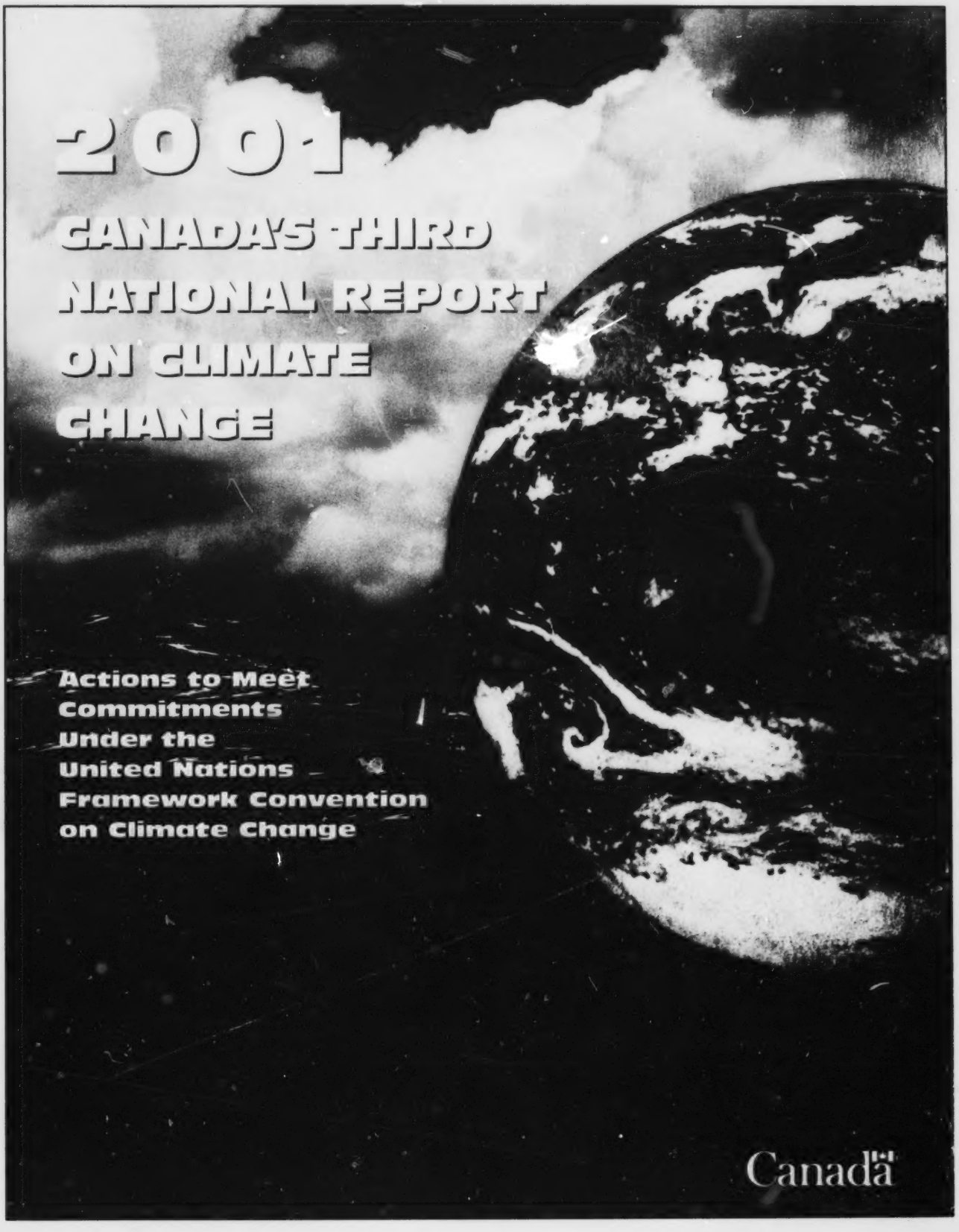

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CANADA'S THIRD NATIONAL REPORT ON CLIMATE CHANGE

Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change

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CANADA'S THIRD NATIONAL REPORT ON CLIMATE CHANGE

Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change

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List of Acronyms, Abbreviations, and Units

AAFC	Agriculture and Agri-Food Canada
AESI	Agricultural Environmental Stewardship Initiative
AMG	Analysis and Modelling Group
bbl	barrel
BERMS	Boreal Ecosystem Research and Monitoring Study
BIOCAP	BIOCAP (Biosphere Implications of CO_2 Policy in Canada) Canada Foundation
BPI	Baseline Protection Initiative
CANMET	Canada Centre for Mineral and Energy Technology
CARC	Canadian Agri-Food Research Council
CBM-CFS2	Carbon Budget Model of the Canadian Forest Sector 2
CCA	Capital Cost Allowance
CCAF	Climate Change Action Fund
CCCma	Canadian Centre for Climate modelling and analysis
CCERP	Cuba–Canada Environmental Restoration Partnership
CCFI	Climate Change Funding Initiative
C-CIARN	Canadian Climate Impacts and Adaptation Research Network
CCME	Canadian Council of Ministers of the Environment
CCPB	Canadian Climate Program Board
CCS	Climate Change Secretariat; Canada Country Study
CDM/JI	Clean Development Mechanism/Joint Implementation
CEO	Canada's Emissions Outlook: An Update
CEO99	Canada's Emissions Outlook: An Update (released in 1999)
CES	Canadian Environmental Solutions
CETB	CANMET Energy Technology Branch
CF_4	carbon tetrafluoride or perfluoromethane
C_2F_6	carbon hexafluoride or perfluoroethane
CFC	chlorofluorocarbon
CFCAS	Canadian Foundation for Climate and Atmospheric Sciences
CFS	Canadian Forest Service
CGHGI	Canada's Greenhouse Gas Inventory
CH_4	methane
CICS	Canadian Institute for Climate Studies
CIDA	Canadian International Development Agency
CIPEC	Canadian Industry Program for Energy Conservation
CLiMRI	Canadian Lightweight Materials Research Initiative
CO_2	carbon dioxide
CO_2 eq.	carbon dioxide equivalent
CoP	Conference of the Parties (signatories to the UNFCCC)
CRF	Common Reporting Format
CRN	Climate Research Network
CRYSYS	Cryospheric Systems
CTI	Climate Technology Initiative
DET	domestic emissions trading
DMS	dimethylsulphide
EAU	enhancing awareness and understanding
EF	emissions factor
eq.	equivalent

FACE	Free-Air CO_2 Enrichment
FBI	Federal Buildings Initiative
FCCC	Framework Convention on Climate Change
FCM	Federation of Canadian Municipalities
FNBP	First National Climate Change Business Plan (part of the NIS)
G7	Canada, France, Germany, Italy, Japan, United Kingdom, United States
G8	Canada, France, Germany, Italy, Japan, Russian Federation, United Kingdom, United States
GCOS	Canada's Global Climate Observing System
GCTE	Global Change and Terrestrial Ecosystems
GDP	gross domestic product
GEF	Global Environment Facility
GERT Pilot	Greenhouse Gas Emission Reduction Trading Pilot
GEWEX	Global Energy and Water Cycle Experiment
GHG	greenhouse gas
GMEF	Green Municipal Enabling Fund
GMIF	Green Municipal Investment Fund
GW	gigawatt
GWP	global warming potential
ha	hectare
HCFC	hydrochlorofluorocarbon
HDD	heating degree-day
HDDV	heavy-duty diesel vehicle
HDGV	heavy-duty gasoline vehicle
HFC	hydrofluorocarbon
IAI	Inter-America Institute for Global Change Research
ICEF	India–Canada Environment Facility
IDRC	International Development Research Centre
IEA	International Energy Agency
IERD	Industry Energy Research and Development
IGBP	International Geosphere Biosphere Program
INBAR	International Network for Bamboo and Rattan
IPCC	Intergovernmental Panel on Climate Change
IRAP	Industrial Research Assistance Program
ITS	Intelligent Transportation Systems
JGOFS	Joint Global Oceans Flux Study
kt	kilotonne
kWh	kilowatt-hour
LDDT	light-duty diesel truck
LDDV	light-duty diesel vehicle
LDGT	light-duty gasoline truck
LDGV	light-duty gasoline vehicle
M	million
MAGS	Mackenzie GEWEX Study
mcf	thousand cubic feet
MOPITT	Measurement of Pollution in the Troposphere

MOST	Moving On Sustainable Transportation
MOU	Memorandum of Understanding
Mt	megatonne
MW	megawatt
NAICC-CC	National Air Issues Coordinating Committee — Climate Change
NAISC	National Air Issues Steering Committee
NAPCC	National Action Program on Climate Change
NCCP	National Climate Change Process
ng/m²	nanogram per square metre
NGO	non-governmental organization
NIS	National Implementation Strategy on Climate Change
N_2O	nitrous oxide
NOW	International North Water Polynya Study
NO_x	nitrogen oxides
NRC	National Research Council of Canada
NRCan	Natural Resources Canada
NRTEE	National Round Table on the Environment and the Economy
NSERC	Natural Sciences and Engineering Research Council
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OEE	Office of Energy Efficiency
OPEC	Organization of Petroleum Exporting Countries
P&Ms	policies and measures
PAGES	Past Global Changes
PBI	Provincial Buildings Initiative
PCF	Prototype Carbon Fund (World Bank)
PCP	Partners for Climate Protection
PEO	public education and outreach
PERD	Program of Energy Research and Development
PERT	Pilot Emission Reduction Trading Project
PFC	perfluorocarbon
PFRA	Prairie Farm Rehabilitation Administration
PJ	petajoule
R&D	research and development
REDI	Renewable Energy Deployment Initiative
S&T	science and technology
SADC	Southern Africa Development Community
SBSTA	Subsidiary Body for Scientific and Technological Advice
SF_6	sulphur hexafluoride
SIA	science, impacts, and adaptation
SSHRC	Social Sciences and Humanities Research Council
SUV	sport utility vehicle
t	tonne
TEAM	Technology Early Action Measures (component of CCAF)
TPC	Technology Partnerships Canada
TWh	terawatt-hour

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VCR	Voluntary Challenge and Registry Inc.
WCRP	World Climate Research Programme
WGCM	Joint Scientific Committee/Climate Variability and Predictability Project Working Group on Coupled Modeling
WGNE	Working Group on Numerical Experimentation
WOCE	World Ocean Circulation Experiment
yr	year

Executive Summary

In 1992, Canada joined more than 150 nations as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit in Brazil. The goal of the UNFCCC was to promote sustainable development, and, at that time, an objective was set out for developed countries to return net greenhouse gas (GHG) emissions to 1990 levels by the year 2000.

As part of their commitment, signatories to the UNFCCC are obligated to provide an accurate and comprehensive report to the UNFCCC Secretariat, following a very specific set of guidelines. These reports, or "national communications," provide updated information on a country's mitigation and adaptation responses to climate change.

The first two national communications were respectively submitted to the UNFCCC Secretariat in 1993 and 1997. The current report, Canada's Third National Report on Climate Change, comprises the following main elements:

- an overview of Canada's National Implementation Strategy on Climate Change (NIS) and resulting key policies and measures;
- a summary of Canada's national GHG inventory and projections of emissions to 2020; and
- an overview of the science, impacts, and adaptation issues facing Canada in the future.

The Third National Report on Climate Change also discusses the unique set of national circumstances underlying Canada's GHG emissions, financial contributions and technological transfer to developing countries, and the scope of public education and outreach programs.

In comparison with the early stages of climate change activity, the Third National Report on Climate Change reflects a significant increase in Canada's climate change activities resulting from the 1997 Kyoto Protocol to the UNFCCC. If the Kyoto Protocol is ratified, Canada will have to reduce its GHG emissions to 6% below 1990 levels during the 2008–2012 commitment period. Some of the key highlights of Canada's Third National Report on Climate Change are as follows:

- Since 1995, the Government of Canada has spent around $1.95 billion[1] to develop new climate change programs and enhance existing ones in an effort to meet its various climate change commitments.
- Between 1990 and 1999, emissions increased by 15%. Nevertheless, Canada managed to reduce the pace of emissions growth, reducing by the same token its gap to achieve its Kyoto target. Had Canada taken no actions on climate change during the past decade, it would have faced a projected gap of 31% in 2010.
- As a result of implemented or planned climate change–related initiatives, it is projected that in 2010, Canada will have to reduce its GHG emissions by 19% to meet its Kyoto target.
- Some of the biggest challenges that Canada faces in terms of emissions mitigation are economic and population growth and increasing exports of energy to the United States.

These key highlights are discussed in more detail below.

NATIONAL IMPLEMENTATION STRATEGY ON CLIMATE CHANGE (NIS)

As a follow-up to Canada's signing of the UNFCCC, the National Action Program on Climate Change (NAPCC) was formulated in 1995. The NAPCC marked the beginning of a national strategy designed to address climate change science, GHG emissions mitigation, and adaptation to climate change. In 1998, the Government of Canada established the National Climate Change Process (NCCP) in an effort to initiate early action to address climate

1 Unless stated otherwise, all monetary figures reported in the Third National Report on Climate Change are in Canadian dollars.

change and build a broader policy foundation. The NCCP was essential to developing a coordinated Canadian response to climate change that would build on more than a decade of actions by all jurisdictions.

After two years of extensive consultations with 450 representatives from stakeholders, non-governmental organizations, citizens, governments, and academics, the federal, provincial, and territorial governments agreed to adopt an overarching National Implementation Strategy on Climate Change (NIS) in October 2000. The NIS provides a broad framework that incorporates a risk management approach to climate change and coordinates action in a phased manner. Phase One of the NIS will be in force until an effective international agreement is ratified. Adopting a phased approach allows for progressive action in response to changing domestic and international circumstances.

The NIS addresses the issue of climate change by taking immediate action to reduce risk and to improve our understanding of the risks associated with climate change, as well as the costs and consequences of reducing emissions and adapting to a changing environment. Under the NIS, governments will be responsible for outlining a suite of intended policies, measures, and other actions in a series of annually updated three-year business plans. The first of these plans, the First National Climate Change Business Plan (FNBP), was publicly released in October 2000 under the key themes of the NIS and covering a number of key sectors, including the electricity, transportation, industry, municipal, agriculture, forestry (sinks), and building sectors.

As part of its FNBP contribution, the Government of Canada released its Action Plan 2000 on Climate Change. Action Plan 2000 sets the course for further action in many sectors of the Canadian economy and lays the groundwork for the long-term behavioural, technological, and economic change that is needed to reduce GHG emissions. Through Action Plan 2000, the Government of Canada will invest $500 million over five years on specific actions to reduce GHG emissions and address key gaps in the understanding of climate science, impacts, and adaptation research.

When fully implemented, Action Plan 2000 will reduce Canada's GHG emissions by about 65 megatonnes (Mt) per year during the 2008–2012 commitment period, taking us one-third of the way to meeting Canada's Kyoto target. Similar provincial business plans are in the formulation stage, and possible outcomes are not yet calculated; however, the projected benefits are likely to be significant.

A summary of the major policies and measures affecting GHG emissions by sector, and by all jurisidictions (federal, provincial, territorial, and municipal governments), is provided in Appendix 1, Table 1, of the report.

NATIONAL CIRCUMSTANCES

Elements of Canada's national circumstances and their influence on GHG emissions and response strategies need to be understood. This is key to putting in context Canada's progress on climate change, understanding the practical impacts of climate change on our economy, environment, and health, and developing further mitigation and adaptation strategies.

Canada's vast geography, natural resources production, export-oriented economy, dispersed population, northern climate, and high population growth all contribute to increased energy demand — a key determinant of GHG emissions levels. Although Canada is developing a high-tech, knowledge-based economy, its resource-based economy remains highly energy-intensive. Moreover, in the last decade, an increasing amount of energy has been exported abroad. While this has a positive impact on the economy of the country, it generates more GHG emissions for which Canada has the responsibility.

In response, Canada is continuing to make significant efforts to reduce the impact that human (anthropogenic) activities have on GHG emissions. Canada is a world leader in developing energy efficiency technologies and practices. Action Plan 2000 measures highlight the importance of these activities and others in related areas, such as fuel switching, promoting renewable energy, and promoting alternative modes of transportation.

INVENTORY OF GHG EMISSIONS AND PROJECTIONS

As outlined in Chapters 3 and 5, between 1990 and 1999, Canada's GHG emissions increased by 15%. Significant economic and population growth played major roles in these GHG emissions increases. Moreover, these increases were exacerbated by national circumstances, increases in coal consumption for electricity generation, due in part to the temporary shutdown of some nuclear power stations, growth in fossil fuel production, mainly for export, and increases in Canadian transportation energy consumption. However, it should be noted that, as of 1999, Canada has seen major improvements in per capita GHG emissions and reductions in annual growth rates. Had Canada taken no actions on climate change during the past decade, by 2010 it would have faced the task of reducing its emissions by 259 Mt (31%). Instead, due to the reduction expected from Action Plan 2000 and other climate change–related initiatives, it is projected that Canada will have to reduce its GHG emissions by 134 Mt (19%) to meet its Kyoto target.

VULNERABILITY ASSESSMENT AND ADAPTATION

The magnitude, timing, and regional impacts of climate change could have serious repercussions on Canada's natural resources, wildlife habitat, social and economic systems, and infrastructure, as well as on the health and general well-being of Canadians. While there may be positive impacts associated with global warming, Canada's vulnerability to extreme weather events such as droughts, floods, hurricanes, and violent thunderstorms could also increase. Impacts of climate change on, for example, precipitation and evapotranspiration could affect soil moisture levels and erosion, water quality and safety, surface water and groundwater levels, hydrologic cycle variability and predictability, and wetland area extent. As a result, the following sectors of the economy could be affected: agriculture, forestry, fisheries, tourism, municipal water supplies, and water transportation. The full range of climate change impacts will influence virtually every sector of the Canadian economy, as well as aspects of our cultural identity.

In this regard, identifying risks and adaptation options that are sustainable over time is of great importance. Understanding the climate system is also crucial for addressing climate change in an appropriate way — both for mitigation and for adaptation. Canada continues to take action to improve its understanding of the science of climate change.

Canada is working towards improvement of its research networks, enhancement and coordination of systematic observations, better understanding of the function of biological GHG sources and sinks, and development of statistical and analytical tools to understand changes in climate. The Government of Canada established the Canadian Foundation for Climate and Atmospheric Sciences to undertake some of these key activities.

This research on climate change related to climate science, impacts, adaptation, and vulnerability is being done by a number of different agencies within the country, including federal and provincial agencies and universities.

FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

In fulfilment of its obligations under the UNFCCC, Canada has contributed substantial resources and assistance toward capacity building and the transfer of environmentally sound technologies to a wide range of countries. In addition to meeting our commitments under the Convention, these international efforts work to address the global nature of climate change. Technology transfers and capacity-building programs represent important steps in enabling action on climate change, as well as engendering global sustainable development practices.

A significant part of Canada's official development assistance program (ODA) provides support to multilateral institutions such as the Global Environment Facility (GEF), several United Nations programs, as well as regional development banks. Country to country assistance, or bilateral aid, also supports a large proportion of actions that contribute to assisting developing countries in managing climate change. Ongoing and new initiatives include the signing of several memoranda of

understanding (MOU) with various countries, research initiatives, technology transfer and capacity-building programs, and special funds dedicated to helping developing countries to manage the causes and effects of climate change.

PUBLIC EDUCATION AND OUTREACH

Federal, provincial, territorial, and municipal governments, along with environmental organizations, educational institutions, and private industries, all play a vital role in informing the public on climate change. Since public understanding of climate change is crucial, the Government of Canada has developed a national strategy on education, training, and public awareness: Reaching Out to Canadians on Climate Change: A Public Education and Outreach Strategy. This strategy focuses primarily on building awareness of climate change among Canadians and encourages them to take personal action to reduce GHG emissions.

CONCLUSION

The environmental, social, and economic well-being of all Canadians may depend on how well we respond to climate change. As outlined in the Third National Report on Climate Change, Canada is active on all fronts to address climate change. Analysis, planning, and actions in the field of science, mitigation, and adaptation are all well under way. Canada's NIS emphasizes the importance of managing risks associated with the climate change issue. Policies and measures at every level of government have had, and will continue to have, a significant impact on levels of GHG emissions.

Canada will continue to work internationally and domestically to develop appropriate adaptation and mitigation strategies to climate change. As a key to the successful realization of these strategies, constant efforts to foster the understanding of climate change among Canadians and their engagement in implementing solutions will also be pursued.

CHAPTER 1 Introduction

CLIMATE CHANGE

The Earth's temperature is determined in part by a naturally occurring heat-retaining process known as the "greenhouse effect." Without this natural process, the Earth's average temperature would be -18°C instead of the current 15°C. The greenhouse effect depends on a number of "greenhouse gases" (GHGs) that are present in the atmosphere: water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and chlorofluorocarbons (CFCs). GHGs trap the sun's heat near the Earth's surface, raising the Earth's temperature and making life on Earth possible.

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." While certain GHGs are naturally occurring, human activities — primarily those that use energy, but also global deforestation and agricultural activities — release additional GHGs into the atmosphere. Of these anthropogenic (human-induced) GHGs, three are of primary concern, as they represent the major human contribution to climate change:

- *Carbon dioxide*: An increasing amount of carbon dioxide is released by the burning of fossil fuels (coal, oil, natural gas) for industrial purposes, transportation, and the heating/cooling of buildings, as well as by deforestation.

- *Methane*: An increasing amount of methane is released by landfills, wastewater treatment, solid waste incineration, certain agricultural practices, and grazing cattle.

- *Nitrous oxide*: An increasing amount of nitrous oxide is released into the atmosphere through practices such as the use of chemical fertilizers and the burning of fossil fuels.

The scientific consensus, as reflected by the Intergovernmental Panel on Climate Change (IPCC), is that incremental GHG emissions caused by human activity since the Industrial Revolution are having a discernible impact on the climate. In the IPCC's view, while human activity may cause only about 5% of global GHGs (with natural processes accounting for the remainder), it is enough to upset the delicate balance of GHGs in the atmosphere and, by extension, the climate. The result is the continued warming of the atmosphere and resulting changes in its composition.

As documented in Table 1.1, after many centuries of GHG stability in the atmosphere, the concentration of GHGs has increased significantly over the past 150 years. Working Group I of the IPCC reports in its Third Assessment Report on Climate Change (IPCC, 2001) that the globally averaged temperature is projected to increase by 1.4–5.8°C over the period 1990–2100.

CANADA'S COMMITMENTS UNDER THE UNFCCC

On December 4, 1992, Canada ratified the UNFCCC, which entered into force on March 21, 1994. The ultimate objective of the UNFCCC is the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to enable ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and enable economic development to proceed in a sustainable manner.

Canada, like other parties to the Convention, has the opportunity to choose the climate change mitigation measures that are the most environmentally and economically effective, given its national circumstances. Under the UNFCCC, Canada is committed to:

- adopt measures to mitigate climate change by addressing anthropogenic emissions by sources, and removals by sinks, of all GHGs. These measures must also be published and regularly updated;

Table 1.1 Current Greenhouse Gas Concentrations

Gas	Pre-industrial Concentration (1860)	Concentration in 1999	Rate of Concentration Change[a]	Atmospheric Lifetime
CO_2	280 ppm	365 ppm	1.5 ppm/yr[b]	5–200 yr[c]
CH_4	~700 ppb	1 745 ppb	7.0 ppb/yr[b]	12 yr[d]
N_2O	~270 ppb	314 ppb	0.8 ppb/yr	114 yr[d]
CFC-11	0 ppt	268 ppt	-1.4 ppt/yr	45 yr
HCFC-23	0 ppt	14 ppt	0.55 ppt/yr	260 yr
CF_4	40 ppt	80 ppt	1 ppt/yr	>50 000 yr

ppm = parts per million

ppb = parts per billion

ppt = parts per trillion

HCFC = hydrochlorofluorocarbon

CF_4 = perfluoromethane

(a) Rate is calculated over the period 1990–1999.

(b) Rate has fluctuated between 0.9 and 2.8 ppm/yr for CO_2 and between 0 and 13 ppb/yr for CH_4 over the period 1990–1999.

(c) No single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes.

(d) This lifetime has been defined as an "adjustment time" that takes into account the indirect effect of the gas on its own residence time.

- formulate measures to facilitate adequate adaptation to climate change;
- promote and cooperate in the development and transfer of technologies and practices to control, reduce, or prevent anthropogenic GHG emissions;
- promote sustainable development approaches, e.g., promote the conservation and enhancement of sinks and reservoirs of all GHGs, and take into account climate change in economic and environmental decision making;
- promote and cooperate in the exchange of scientific, technological, and socio-economic information related to climate change, by working nationally on data collection, research, and systematic observation to further understanding of climate change;
- provide new and additional financial resources to help developing countries comply with their obligations under the UNFCCC;
- promote, facilitate, and finance the transfer of environmentally sound technologies to developing countries, enabling them to implement the provisions of the Convention; and
- collaborate with other countries to ensure that the policy instruments they use to reduce climate change complement, rather than counteract, measures taken elsewhere.

The Kyoto Protocol was negotiated at the Third Conference of the Parties (signatories to the UNFCCC) in December 1997 and signed by Canada in 1998. If the Protocol is ratified and comes into force, it would set binding emissions targets for developed countries for the five-year period 2008–2012. Canada's commitment would require reductions from the basket of GHGs (carbon dioxide, methane, nitrous oxide, HFCs, PFCs, and sulphur hexafluoride) to 6% below 1990 levels during that period.

CANADA'S RESPONSES TO CLIMATE CHANGE

Immediately following the signing of the Kyoto Protocol, Canada's First Ministers launched a national process to examine the implications of

Kyoto for Canada and develop a strategy for responding to it. The 1998 Government of Canada budget announced the introduction of the Climate Change Action Fund (CCAF). Through the CCAF, $150 million was allocated over three years to support the development of an implementation strategy to begin meeting the Kyoto commitments and facilitate early action to reduce GHG emissions. The February 2000 Government of Canada budget announced the extension of the CCAF until 2003–2004 and committed an additional $600 million over five years toward increased action on climate change.

The national climate change process led to the release in October 2000 of Canada's National Implementation Strategy on Climate Change (NIS) and the accompanying First National Climate Change Business Plan (FNBP). Phase One of the NIS outlines a series of actions to manage Canada's risks associated with climate change. This phase focuses mainly on GHG emissions mitigation and adaptation and is organized around the following five themes:

- enhancing awareness and understanding;
- promoting technology development and innovation;
- governments leading by example;
- investing in knowledge and building the foundation; and
- encouraging action — sectoral, cross-sectoral, and cross-cutting.

The FNBP provides an umbrella for individual and cooperative federal, provincial, and territorial actions under these key themes of Phase One of the NIS. The FNBP attempts to tackle the impacts of climate change, outline adaptation strategies, increase public awareness, encourage individual and corporate actions, and increase opportunities through technological development. As part of its contribution to the FNBP, the Government of Canada released its Action Plan 2000 on Climate Change, through which it is investing an additional $500 million on specific actions to reduce GHG emissions.

NATIONAL COMMUNICATIONS UNDER THE UNFCCC

Canada's First National Report on Climate Change, published in 1994, was a description at that time of what had been done by governments, communities, and the private sector with respect to Canada's commitments in the areas of climate change mitigation, adaptation, research, education, and international cooperation. The Second National Report on Climate Change, dated May 1997, was drafted under guidelines provided by the Subsidiary Body for Scientific and Technological Advice (SBSTA) to provide an update of Canada's situation and additional responses to climate change.

Guidelines for the publication of these national communications to the UNFCCC are produced by the SBSTA. They are designed to assist Parties in meeting commitments to develop, update, publish, and make available national inventories of emissions by source, and removal by sinks, of all GHGs not controlled by the Montreal Protocol. The guidelines also aim to promote the provision of consistent, transparent, comparable, and accurate information in the development of national communications and to ensure that the Conference of the Parties has enough information to review the implementation of the Convention.

CANADA'S THIRD NATIONAL REPORT ON CLIMATE CHANGE

Canada's Third National Report on Climate Change provides an update of Canada's current status and responses to climate change, as requested in the SBSTA guidelines. Canada's national strategy to address climate change is elaborated in various sections of this document, which is organized as follows:

- Chapter 2: National Circumstances
- Chapter 3: Greenhouse Gas Inventory Information[2]
- Chapter 4: Policies and Measures

2 It should be noted that Chapter 3, "Greenhouse Gas Inventory Information," is a summary of a more comprehensive report on Canada's GHG inventory from 1990 to 1999 that was released in 2001.

- Chapter 5: Emission Projections to 2020
- Chapter 6: Vulnerability Assessment, Climate Change Impacts, and Adaptation Measures
- Chapter 7: Financial Resources and Transfer of Technology
- Chapter 8: Research and Systematic Observation of Climate Change
- Chapter 9: Education, Training, and Public Awareness

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CHAPTER 2 National Circumstances

INTRODUCTION

Canada's anthropogenic (human-induced) greenhouse gas (GHG) emissions on a per capita net basis (gross emissions less removals) are relatively high compared with those of most other nations. Canada has roughly 0.5% of the world's population but accounts for about 2.2% of total global GHG emissions. On a per capita basis, Canada ranks ninth in the world (Figure 2.1) and second in the G8 for carbon dioxide (CO_2) emissions (Figure 2.2) from fuel combustion. This is due to a variety of factors, in particular Canada's growing energy-intensive economy. Canada ranks second in the G8 for gross domestic product (GDP) growth rate (Table 2.1). From 1990 to 1999, Canada's per capita GHG emissions rose much less quickly than per capita GDP: 3.9% vs. 13.5%.

The interaction of structural (fixed/unchanging) and variable characteristics determines the nature and extent of anthropogenic GHG emissions and removals. We define this context for GHG emissions as "national circumstances." National circumstances affect a country's production and use of energy and, in turn, its vulnerability to the potential impacts of climate change. This chapter focuses on structural characteristics that determine Canada's energy use, energy intensity,[3] and GHG emissions levels. (For further details on Canada's GHG emissions, see Table 2.2.)

Although Canada is developing a high-tech, knowledge-based economy, the development and export of renewable and non-renewable resources (such as energy, agricultural and fisheries products, forest products, water, and minerals) continue to play an important role. The production, transformation, and consumption of energy are responsible for most of carbon dioxide and methane (CH_4) in Canada. In 1999, energy use accounted for about 80% of Canada's total GHG emissions. Other GHG emissions, mainly nitrous oxide (N_2O), come mostly from non-energy sources, such as agriculture/livestock, industrial processes, and waste disposal.

The structural characteristics described in this chapter highlight the challenges faced by Canada as it tries to reduce GHG emissions, challenges that are not faced by most other countries. Canada's structural characteristics include:

- physical characteristics related to its geography, climate, and population; and
- economic structure/activity related to its level of resource-based activity and exports.

The factors outlined above result in relatively high levels of GHG emissions for Canada in relation to particular regions, sectors, and industries. The combination of these factors can also limit the range of options available for climate change mitigation and adaptation efforts and/or the eventual effectiveness of the design, implementation, and impact of subsequent actions.

The following sections outline the link between Canada's structural characteristics and its GHG emissions.

PHYSICAL CHARACTERISTICS

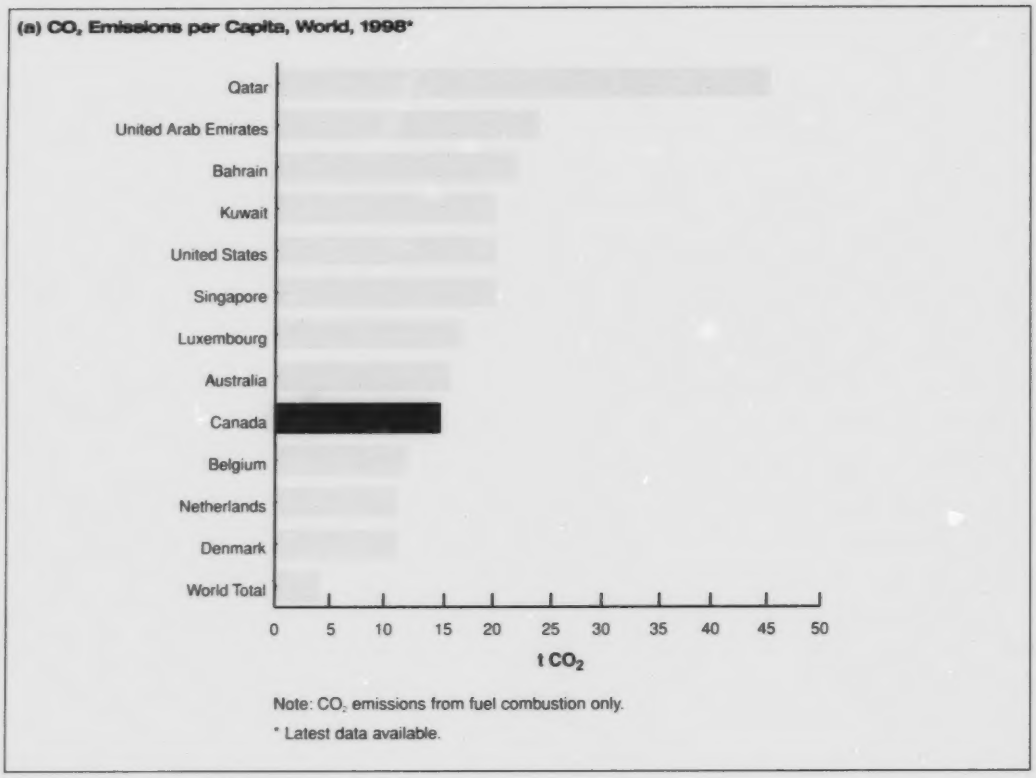
Geographic Size and Population

Canada is a land of physical extremes and contrasts. Its surface area of land plus fresh water occupies 9 970 620 km² or 7% of the world's land mass. Canada extends roughly 5 300 km east to west — the distance between Paris and New York — and nearly 4 600 km north to south.

Despite being the second largest country in the world by area, Canada supports a relatively small population (roughly 31 million in 2000) that is only 0.5% of the global population. Its average population density is low, at about three persons per square kilometre. About 80% of the population is concentrated in major urban areas spread out along the Canada–U.S. border. Occupied urban areas account for less than 20 000 km², or roughly 0.2% of the country's total land area. Increasingly, Canadians have congregated in the largest cities; nearly 60% of

3 Energy intensity is defined as GHG emissions per unit of economic activity.

Figure 2.1 CO_2 Emissions per Capita, (a) World 1998 and (b) Annex B Countries



Canada's urban population lives in centres of 500 000 or more people.

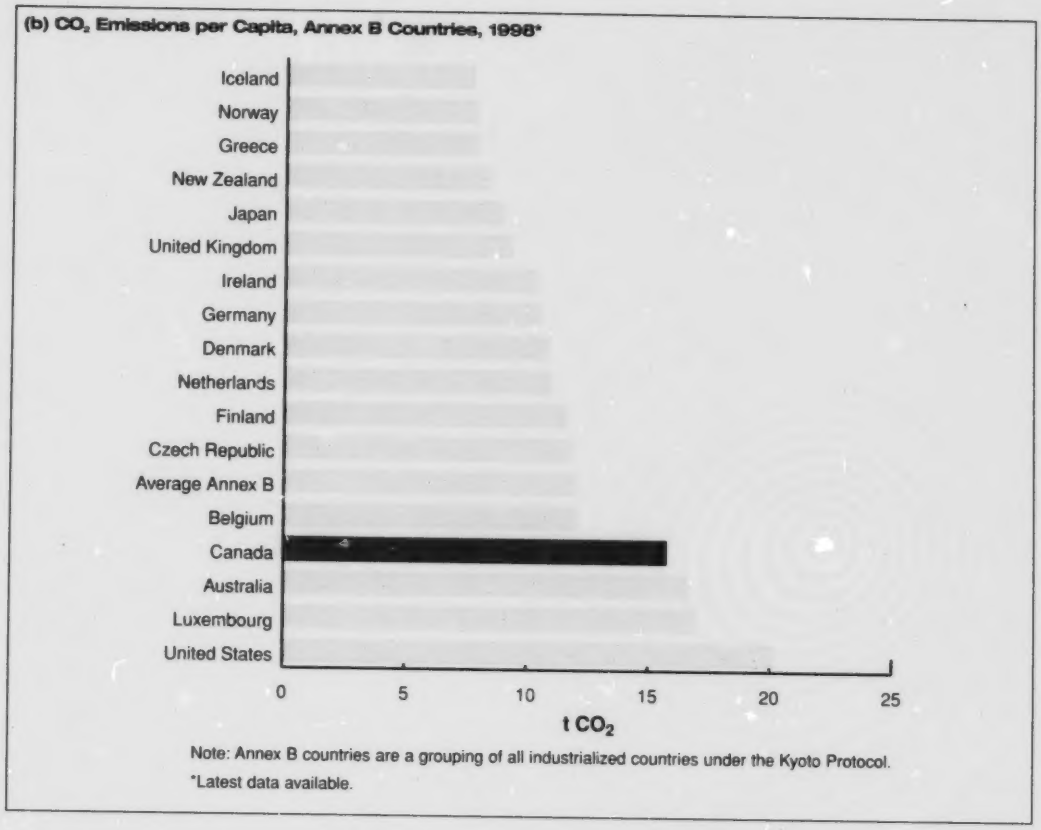
Canada's widely dispersed urban clusters, small population, and low population density all contribute to relatively high per capita energy use and GHG emissions in the transportation sector, especially road transportation for passengers and freight. On the passenger side, the need to travel long distances both within and between urban centres promotes a greater reliance on private vehicles than in many other countries. In the late 1990s, average annual distance travelled by light vehicles in Canada was around 16 935 km per vehicle, compared with an average of approximately 14 226 km per vehicle in European countries of the Organisation for Economic Co-operation and Development.

Canada is a producer and exporter of large volumes of natural resources, and the long distances between extraction/production and points of consumption/export locations also contribute to relatively high per capita energy use in the transportation sector. Canada moves over three times as much freight measured in tonne-kilometres per capita as Japan and all major Western European countries. Canada's manufacturing, wholesaling, and retail distribution systems face a similar transportation challenge due to the dispersal of markets. This dispersal results in significantly higher energy use for freight movement.

Climate

Some countries have very uniform climates, while others have widely diverse regional and/or seasonal variations, including harsh winter conditions. Few nations, however, can match the climatic diversity of Canada. This country, with its large and varied land mass and three ocean boundaries, has 15 terrestrial ecozones. These range from the Arctic Cordillera ecozone, which has an extremely cold and dry climate and

Figure 2.1 ***(continued)***



continuous permafrost, to the Mixedwood Plains ecozone, which has a cool to mild, moist climate. (See map of ecozones at the Environment Canada Web site: www.ec.gc.ca/soer-ree/English/Framework/NarDesc/canada_e.cfm.)

Overall, Canada is characterized by relatively short, intense summers with wide temperature variations and long, cold winters. Table 2.3 compares Canadian cities with non-Canadian cities in terms of average annual heating degree-days[4] over a 10-year period. Greater heating requirements, as reflected in the numbers outlined below, result in high per capita use of energy in Canada for heating during colder months. Cooling requirements during hot summer months further increase energy use.

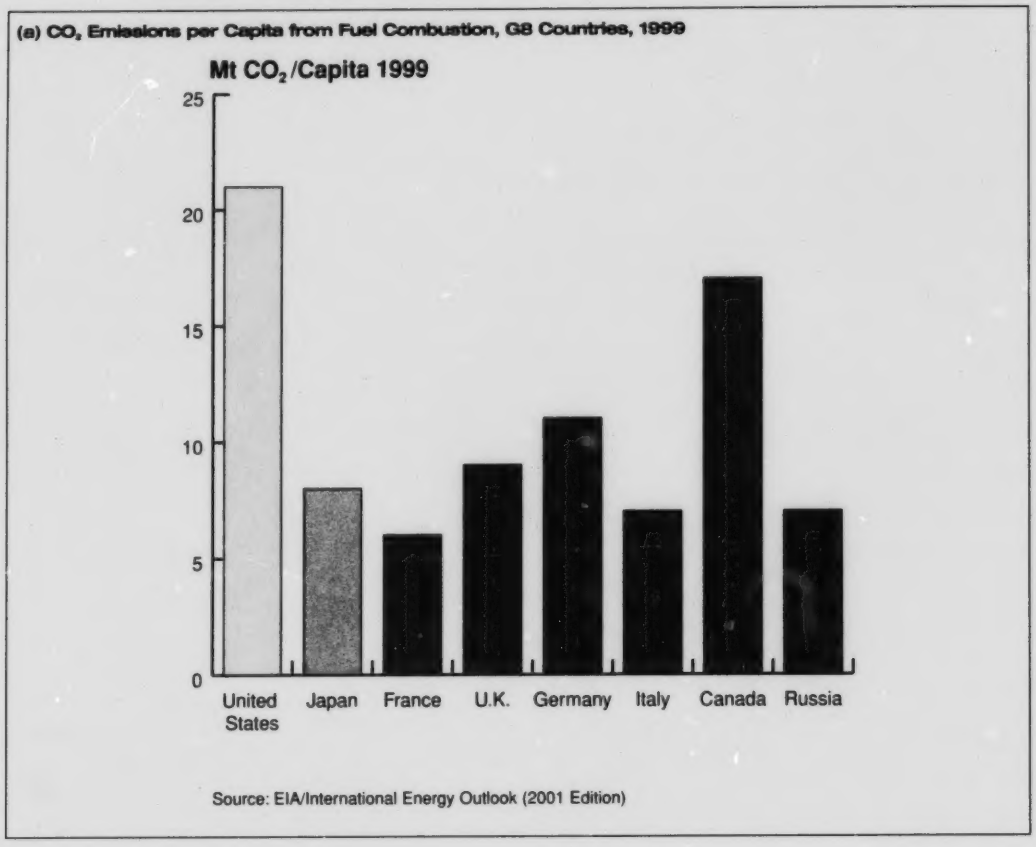
ECONOMIC STRUCTURE/ACTIVITY

Canada's economic structure, a combination of energy-intensive industries and significant production and refining of natural resources, contributes to higher domestic GHG emissions levels. The aggregate energy intensity[5] of industry, transportation, and the residential/commercial sectors of the Canadian economy in 1999 was approximately 0.29. In comparison, the same sectors in the United Kingdom, Germany, France, and Italy had average energy intensity levels ranging from 0.09 to 0.13. These countries generally have a higher proportion of light industries that are less energy intensive as measured by the amount of energy used per unit of GDP.

4 Calculated by multiplying the number of days the average temperature is less than 18°C by the number of degrees the average temperature is below 18°C over a year-long period.

5 Tonnes of oil equivalent per US$1 000 at 1995 prices and exchange rates.

Figure 2.2 (a) CO_2 Emissions per Capita from Fuel Combustion and (b) GDP per Capita, G8 Countries, 1999



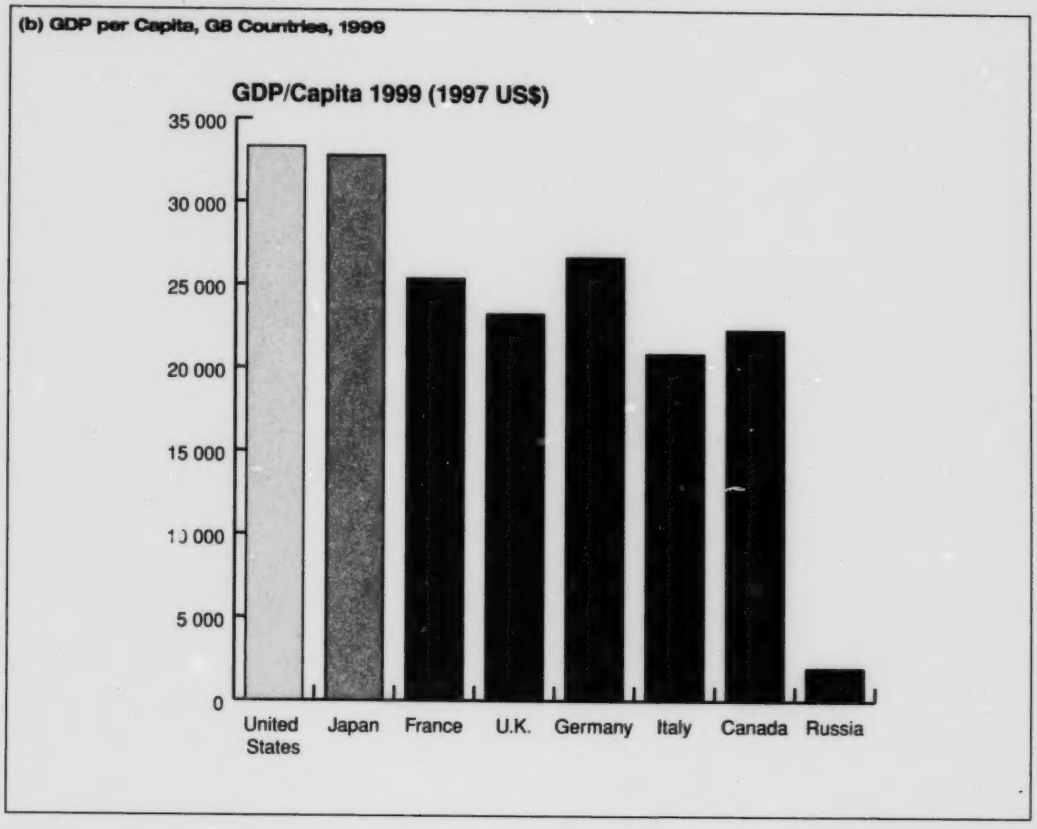
The varying patterns of economic growth and associated GHG emissions levels across Canada reflect the differing structures of provincial economies and their respective patterns of production and consumption of fossil fuels. Ontario and Quebec are the most industrialized and heavily populated provinces and are major users of fossil fuels, Alberta is a major fossil fuel producer, and Atlantic Canada increasingly produces fossil fuels but is generally less industrialized. Given that all orders of government in Canada are committed to seeing that no region bears an unreasonable burden in meeting the Kyoto targets, it is a challenge to design the appropriate mix of policies and measures to address climate change.

Canada's economy relies heavily on export markets, with 37% of Canada's total economic output exported in 1999 — an increase of 8.3% since 1990. Canada's reliance on exports is the highest within the G7. In 1998, exports accounted for an average of only 18% of GDP for the G7 as a whole and only 12% of GDP for the United States.[6] Forty percent of Canada's total exports are energy-intensive, resource-based commodities, and more than 50% of Canada's oil and natural gas production was exported to the United States in 1999. (It should be noted that 78% of all Canadian exports are destined for the United States.)

The importance of energy (oil and natural gas), agriculture, forestry, fisheries, water resources, and mineral resources to the Canadian economy is highlighted below:

6 Data for 1998 are the latest currently available.

Figure 2.2 ***(continued)***



- The energy, mineral, and forestry sectors account for 11% of Canada's GDP or $88 billion a year and combine to generate 780 000 direct jobs and about an equal amount of indirect employment.
- Conventional energy sources, defined as fossil fuels and electricity generated from oil, gas, coal, and nuclear sources, contribute over 7% to Canada's GDP, stimulate annual investment of approximately $24 billion, and directly employ nearly 280 000 people.
- Five of the 10 leading industries in GDP per hour of labour are resource-based.
- Canada's natural resource industries are responsible for close to $100 billion annually in exports and a trade surplus of $60 billion.
- Since 1985, the level of natural gas exports to the United States has quadrupled to 3.4 trillion cubic feet. Canadian gas now meets about 15% of total U.S. demand.
- Canadian resource companies invest about $35 billion per year in new capital equipment. This represents 22% of the nation's annual total investment.
- World demand for forest products is forecast to increase by 25% from 1996 to 2010.
- Global requirements for minerals and metals are expected to grow by at least 30% from 1996 to 2010.
- Natural gas exports to the United States are likely to increase significantly between now and 2010.

Table 2.1 Comparative GDP Growth Rates, G8 Countries

	GDP Growth Rate (%)						
	U.S.A.	Canada	U.K.	France	Germany	Italy	Japan
1990–1998	27	19	17	12	15	9	12
1990–1999	33	25	20	14	16	10	13

Note: Russia (and former Soviet Union states) experienced significant negative growth in GDP (43%) between 1990 and 1999. However, since 1998, Russia has experienced growth in GDP that the International Energy Agency projects will continue until 2020 at an average annual rate of 7.2%.

Table 2.2 Changes in Canada's GHG Emissions and Related Factors, 1990–1999 and 1995–1999

(a) Changes in Canada's GHG Emissions and Related Factors, 1990–1999

Year	GHG Emissions (kt CO_2 eq.)	% Change from 1990	Population (000s)	% Change from 1990	GDP (1992 $M)	% Change from 1990	Primary Energy Demand (PJ)	% Change from 1990
1990	607	0.0	27 817.2	0.0	705 464	0.0	9 604	0.0
1991	600	-1.2	28 126.9	1.1	692 247	-1.9	9 537	-0.7
1992	616	1.5	28 485.5	2.4	698 544	-1.0	9 693	0.9
1993	619	2.0	28 811.7	3.6	714 583	1.3	9 802	2.1
1994	641	5.6	29 140.5	4.8	748 350	6.1	10 178	6.0
1995	658	8.4	29 455.0	5.9	769 082	9.0	10 314	7.4
1996	672	10.7	29 771.7	7.0	780 916	10.7	10 579	10.2
1997	682	12.4	30 076.4	8.1	815 013	15.5	10 623	10.6
1998	689	13.5	30 323.1	9.0	842 002	19.4	10 525	9.6
1999	699	15.2	30 576.0	9.9	880 254	24.8	10 740	11.8

(b) Changes in Canada's GHG Emissions and Related Factors, 1995–1999

Year	GHG Emissions (kt CO_2 eq.)	% Change from 1995	Population (000s)	% Change from 1995	GDP (1992 $M)	% Change from 1995	Primary Energy Demand (PJ)	% Change from 1995
1995	658	0.0	29 455.0	0.0	769 082	0.0	10 314	0.0
1996	672	2.1	29 771.7	1.1	780 916	1.5	10 579	2.6
1997	682	3.6	30 076.4	2.1	815 013	6.0	10 623	3.0
1998	689	4.7	30 323.1	2.9	842 002	9.5	10 525	2.0
1999	699	6.2	30 576.0	3.8	880 254	14.5	10 740	4.1

Table 2.3 Average Annual Heating Degree-Days, Canadian and World Cities, 1989–1998

City	HDDs	City	HDDs
Montreal	4 452	Berlin	3 300
Toronto	3 515	Paris	2 720
Winnipeg	5 821	Washington	2 160
Vancouver	2 783	Tokyo	1 620

Energy Sector (Oil and Gas)

Canada possesses a vibrant energy sector, defined here as covering both crude oil and natural gas. The industry's activities are generally divided into two main sectors: the upstream exploration and production sector and the downstream refining and distribution sector. Alberta is the primary source of crude oil and natural gas in Canada, with British Columbia, Saskatchewan, Newfoundland, Nova Scotia, and Canada's far north also contributing.

Canada is the world's third largest natural gas producer and second largest exporter. Virtually all the natural gas used by Canadians is produced domestically. About half of all homes in Canada use natural gas as the primary source of heating. The electricity generation, industrial, and commercial sectors also use significant amounts of natural gas.

Net GHG emissions associated with Canada's production of crude oil and natural gas solely for the purposes of export are estimated to be as high as 46 Mt annually. The GHG emissions associated with the export of oil and natural gas (i.e., its production and transportation) are attributed to Canada, not the importing country, raising total and per capita emissions attributed to Canada. It should be noted that Canada's natural gas exports contribute to increases in high-efficiency co-generation of electricity and heat in many areas of the United States, resulting in global environmental benefits.

In most cases, Canadian-processed natural resources are exported to other countries for further refining or processing, which is usually less emissions-intensive than the primary production occurring in Canada.

Canada's reserves of crude oil and natural gas are extensive. In 1999, the country produced 122 million cubic metres of crude oil and 168 billion cubic metres of natural gas, yielding revenues of $32.8 billion. The Canadian crude oil market is roughly divided into two, with the boundary running north–south through Sarnia, Ontario. Refineries using crude oil imports dominate the eastern market, while refineries using domestically produced crude oil dominate the western market.

At year-end 1999, Canada's reserves of crude oil stood at over 340 billion barrels, exceeding the proven reserves of Saudi Arabia, while Canada's natural gas reserves stood at about 1 640 billion cubic metres. Production of crude oil and natural gas in Canada has been steadily rising, mainly to satisfy additional demand from the United States.

Over 300 billion barrels of Canada's oil reserves are in the form of bitumen/oil sands. Oil sands production processes generate higher GHG emissions than those associated with conventional oil production. In the last decade, the application of new extraction and upgrading technologies and management efforts to improve energy efficiency have succeeded in reducing GHG emissions per unit of output by 22%. This result is one of the best emissions reductions achievements in Canadian industry. By 2010, the oil sands producers expect to have reduced emissions on a per unit of output basis by 45% from 1990 levels.

Electricity Sector (Production and Consumption)

Canada has one of the most diversified electricity generation systems in the world, with generating sources including hydro-electricity, other renewable and emerging energy sources (wind, solar, biomass, photovoltaic, small hydro), natural gas, oil, coal, and nuclear power. Almost 75% of Canada's electricity is generated by non-GHG-emitting sources, principally hydro and nuclear power, but also biomass and other renewable sources of energy.

The breakdown of GHG-emitting thermal sources of electricity is shown in Table 2.4.

Due to the abundance of hydroelectricity, the electricity sector is one area where Canada possesses a significant advantage over most other nations in its ability to reduce GHG emissions.

Canada is one of the largest hydroelectricity producers and a world leader in long-distance electric power transmission. Canada's hydro generating capacity (66 GW) is the second largest in the world, after the United States. This country ranks 6th in the world in nuclear generating capacity and 13th in conventional thermal generating capacity (total world generating capacity is mainly conventional thermal).

Table 2.4 Thermal Sources of Electricity and GHG Emissions

Thermal Source	% Electricity Production	% GHG Emissions
Coal	18	82
Natural Gas	4	9
Fuel Oil	2.5	9

Canada's installed generating capacity from all energy sources (about 133 GW) ranks sixth in the world (behind the United States, Japan, China, the Russian Federation, and Germany), accounting for 3.6% of the world total.

In Ontario, electricity production is fairly evenly balanced between coal, nuclear, and hydro, while in New Brunswick, electricity production is based on a mix of oil, nuclear, hydro, and coal. In the other provinces, electricity production tends to depend more on one fuel type (Table 2.5).

CARBON SOURCES/SINKS (LAND USE/LAND CHANGES)

Canada plays an important role in the global carbon cycle, given its large tracts of forests and agricultural lands. Overall, Canada's 1990–1999 Greenhouse Gas Inventory estimates that Canada's land use change and forestry sector represented a net sink of about 20 Mt carbon dioxide equivalent (CO_2 eq.) in 1999. In addition, agricultural soils were a small net source of 0.2 Mt CO_2 eq., in 1999, down from a source of 7 Mt in 1990. This downward trend is a result of the broader availability and implementation of sustainable management practices.

Sinks In General

Forests and agricultural soils contain large amounts of carbon and are therefore an important component of the global carbon cycle. The total carbon stored in soils alone represents two to three times the amount of carbon present in the atmosphere as carbon dioxide. Key terms in describing the carbon cycle are as follows:

- *reservoir*: a place where a GHG or a GHG precursor is stored (sequestered);
- *carbon stock*: the absolute quantity of carbon held within a reservoir at a given time;
- *carbon sink (removals)*: a stock that is increasing; and
- *carbon source (emissions)*: a stock that is decreasing.

If the inflow of carbon dioxide to a reservoir via photosynthesis is equal to the outflow of carbon dioxide via decomposition and respiration, then no matter how big or small the stock, it is neither a net carbon source nor a sink, but is carbon neutral.

Carbon fluxes between the atmosphere and forests and agricultural soils are an important component of the global carbon cycle. The processes that mediate these fluxes can thus have a significant effect on the global concentration of carbon dioxide in the atmosphere. These processes are described below.

Agricultural soils and forest ecosystems absorb carbon dioxide from the atmosphere in vegetation (tree biomass, standing crops), detritus (material on the forest floor such as rotting leaves and branches), and peat. They routinely exchange carbon with the atmosphere through photosynthesis, respiration, and decomposition. Storing carbon in plant material such as paper, lumber, furniture, building materials, and strawboard also serves as a form of carbon storage. When trees die or are harvested or agricultural soils are eroded, some of the carbon stored in these reservoirs is returned to the atmosphere as carbon dioxide. Through these processes, forest and agricultural ecosystems can act as a carbon sink, act as a carbon source, or be carbon neutral, according to whether their carbon stock is decreasing, increasing, or remaining constant.

Table 2.5 Electricity Production by Fuel Type, Canadian Provinces

Province	% Coal	% Oil	% Natural Gas	% Nuclear	% Hydro	% Other
Alberta	78	0	16	0	4	2
British Columbia	0	0	5	0	89	5
Manitoba	3	0	0	0	97	0
New Brunswick	32	29	0	20	15	4
Newfoundland	0	3	0	0	97	0
Nova Scotia	66	23	0	0	9	2
Ontario	24	1	7	42	24	1
Prince Edward Island	0	100	0	0	0	0
Quebec	0	2	0	2	96	0
Saskatchewan	69	0	9	0	22	1
CANADA	**19**	**3**	**4**	**12**	**60**	**1**

Appropriate agricultural and forest management practices such as harvesting, silvicultural techniques, and protection from insects, diseases, and fire can affect the rate of carbon uptake, storage, and decomposition. A more detailed discussion of sinks and their relationship to Canada's national circumstances is presented below.

Agricultural Sinks and Sources

Canada contains 68 million hectares of farmland, 80% of which is in the Prairie provinces. Two-thirds of this farmland is used for crops and improved pasture (seeded, drained, fertilized, or weeded). The total area under cultivation (cropland plus summer fallow in a given year), covering 41 million hectares, is made up of about 250 000 farms that are 98% family-owned.

Agricultural emissions accounted for 8.7% of Canada's GHG emissions in 1999. Most of these emissions were from non-energy sources, with nitrous oxide accounting for more than 62% of emissions and methane for 38%. (Emissions from all anthropogenic activities within the agricultural sector, excluding fuel combustion, are covered in this section.) Agriculture is also responsible for about 2.6 Mt of GHG emissions due to energy consumption for heating purposes; these emissions are included with those of the building sector.

The growing world population and increasing demand for food are expected to intensify agricultural production and increase Canada's emissions to 72 Mt in 2010, up from 59 Mt in 1990 (see Chapter 5 for more details on projections). However, several trends in the agricultural sector are working to reduce GHG emissions and enhance carbon sequestration in agricultural soils. Examples are increased use of no-till seeding, reduced summer fallowing of cultivation lands, increased biomass production and carbon sequestration through more efficient use of fertilizer, the allocation of additional land to forage crops, the introduction of crop strains with higher yields, improved efficiency in fossil fuel use and greater use of ethanol, and reduced methane emissions from livestock and manure due to improved feeds and management practices.

Carbon sequestration in agricultural soil happens when carbon buildup in the soil (from the residues of plants growing in the soil) exceeds the loss due to decay through cultivation and other processes. It is estimated that Canada has lost about 1 100 Mt of carbon from agricultural soils since cultivation began. The amount of carbon that could be sequestered remains uncertain, with estimates depending upon an array of factors. The sequestration of carbon would occur over a period of decades.

Wetlands are ecologically situated at the interface between land and water and blend attributes of both terrestrial and aquatic systems.[7] They perform an important function in GHG dynamics and cycling. The global extent of these wetlands is not fully known; however, the World Conservation Monitoring Centre estimates that they cover about 6% of the world's surface and contain 14% of the terrestrial biosphere carbon pool. Over 24% of the world's wetlands are estimated to occur in Canada, where 15.9%, or 148 million hectares, of the landscape is classified as wetlands. Appropriate management of wetlands (preservation, restoration) within the context of the agricultural landscape could enhance their ability to sequester carbon.

Wetlands may serve as a greater sink or source of GHGs (carbon dioxide, methane, nitrous oxide) than the productive land adjacent to them. There is also potential for agricultural runoff to produce GHG emissions in adjacent riparian wetlands. Determining the role of wetlands may provide a more accurate assessment of the sink potential of the entire agricultural landscape. Further research is required to determine the net GHG impact of wetlands (carbon inventory and fluxes) and their potential to serve as a carbon sink. This research would include examining the magnitude of GHG sources and sinks, the processes controlling them, agricultural runoff, and the potential for appropriate management regimes to be enacted.

Forest Sinks and Sources

Canada's forest area totals 418 million hectares. Forest covers almost half the country and represents about 10% of the world's total area of forest. About 245 million hectares are considered timber-producing forest. While the forest area that is actively managed has never been defined for administrative purposes, it likely amounts to about one-third of the total forest.

There is no current or planned access to, or management of, a very substantial portion of the total forest due to its remoteness. Canada's forest grows very slowly and is primarily natural, comprising species that in most regions typically take up to 100 years or so to reach their maximum carbon storage potential. The forest has an uneven age-class distribution skewed to the older age-classes mainly due to natural disturbances that have affected the forest over the last century. This means that Canada's forest currently stores a great deal of carbon; however, as the age-class distribution changes, carbon stocks could fall. The greatest share of the forest is boreal forest, which is subject to highly variable natural disturbance patterns due to factors such as fire and insects. As a result, there have been significant carbon stock changes over extended periods of time. For example, in 1990–1997, wildfire burned 0.6–6.3 million hectares of the total forest per year, for an average of 2.6 million hectares per year or 0.4% of the total forest.

The large size of Canada's forest, its slow growth, the relatively young age of Canada as a country, and Canada's relatively small population have produced a largely export-oriented forest products industry that relies on extensive rather than intensive forest management. Long-term sustainability is the management objective. Compared with intensive management, extensive management involves a lower intensity of management over a larger area. To date, almost no afforestation has occurred. (*Afforestation* is defined as the planting or seeding of trees on land that did not recently contain forest, which could be considered reforestation under some definitions.) About 0.25% of the forest is harvested each year, with harvesting and silvicultural practices often designed to emulate, as far as possible, average natural disturbance patterns and frequencies. Natural forest regeneration, a portion of which involves site preparation to assist regeneration, is used successfully as the means of reforestation for about 55% of harvested areas.

Estimates using Canada's national Carbon Budget Model of the Canadian Forest Sector 2 (CBM-CFS2) indicate that Canada's total forest, as opposed to the managed forest, was a large source of GHG emissions in the mid-1980s to mid-1990s after being a sink for an extended period. However, analyses also suggest that the total forest will revert to a carbon sink over

7 The Ramsar Convention provides the most universal definition of wetlands: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

time. Much less is known about the carbon budget of the managed forest, which will respond to changes in management practices, as well as being affected by future climate change. There are scientific concerns that climate change will affect the pattern of natural disturbances in the forest, increasing the risk of emissions.

Canada's 1990–1999 Greenhouse Gas Inventory estimates that Canada's land use change and forestry sector, for the five categories covered in the Inventory, was a net sink of about 20 Mt CO_2 eq. in 1999.

VARIABLE CHARACTERISTICS

Building upon the structural characteristics of Canada's national circumstances, the overarching factor for the majority of GHG emissions is the rates of production, transformation, and consumption of energy across the Canadian landscape. These are the variable components targeted by the various mitigation and adaptation efforts related to climate change.

The variable characteristics — population change, economic growth, and socio-economic issues related to GHG emissions — are factors that can dictate the direction of a country's GHG emissions over a given period. Actions by citizens, industry, non-governmental organizations, and governments can affect the trend of GHG emissions within the context of these factors.

Canada's sustained economic growth commencing in the late 1990s is a major source of growth in GHG emissions. Canadians, in general, enjoy a high quality of life as measured on a variety of social and economic scales. GDP is one example. From 1990 to 1999, Canada's GDP growth rate (25%) was the second highest in the G8, with growth accelerating strongly during the latter half of the decade. This economic growth inevitably increases activity in all sectors of the economy and leads to increased rates of energy use and GHG emissions (see Figure 2.2).

Population growth rates also affect growth in GHG emissions. From 1990 to 1999, Canada had the highest annual population growth rate (1.1%) among G8 countries, mainly due to immigration, and the second highest among countries that have emissions reduction commitments under the Kyoto Protocol. Comparative population growth rates during that period for other G8 countries are as follows: United States 0.8, Germany 0.4, France 0.4, United Kingdom 0.2, Japan 0.2, and Russia 0.1. Canada's population is projected to grow at an annual rate of 0.9% to 2020, raising the current population from 31.0 million to 37.4 million.

This population growth increases demand for the production of goods and services at all levels — for housing, commercial buildings, and transportation infrastructure — and contributes to growth in energy use and GHG emissions.

GOVERNING STRUCTURE

Not all countries have the same system of governance or the same jurisdictional responsibilities for addressing climate change. These aspects can significantly influence the development of policies and measures and need to be carefully considered. The Canadian Constitution does not assign responsibility for environmental protection and other key areas of related public policy to one order of government exclusively. However, the Constitution does assign responsibility for the development of natural resources, a major contributor to climate change, to provincial governments. This division of responsibilities adds a further layer of complexity by necessitating a high degree of cooperation on climate change, environmental assessment, and energy policy among all levels of government in Canada: federal, provincial, territorial, and municipal.

One of Canada's guiding principles on climate change is that no one region should be asked to assume an unreasonable share of the burden for GHG reduction efforts. This guiding principle has policy implications, given Canada's diverse geography and regional economies.

SUMMARY AND CONCLUSIONS

A full appreciation of Canada's challenge in limiting its GHG emissions requires recognition that there are structural characteristics — such as cold climate, expansive geography, and an energy-intensive economic structure — that inherently lead to net higher per capita energy use and GHG emissions in comparison with most other countries. The variable factors influencing GHG emissions, outlined in more detail in Chapters 3 and 4, interact within this structural context, providing for a unique set of national circumstances for reducing emissions. Canadian governments and stakeholders will need to continue to make progress in the pursuit of effective climate change solutions for Canada. We will continue building upon key actions over the past decade, including Action Plan 2000 and the broader First National Climate Change Business Plan, as well as actions by the private sector, such as the Voluntary Challenge and Registry Inc./ÉcoGESte.[8]

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CHAPTER 3 Greenhouse Gas Inventory Information

The Framework Convention on Climate Change (UNFCCC), Article 4(1)(a), Article 12(1)(a), and Decision 3/CP.5, requires Annex I Parties to submit an annual inventory report using UNFCCC guidelines. This report must include an inventory of anthropogenic (human-induced) emissions by sources, and removals by sinks, of all greenhouse gases (GHGs) not controlled by the Montreal Protocol. This chapter of Canada's national report summarizes the net anthropogenic sources (emissions) and sinks (removals) of GHGs for Canada in 1999 and discusses underlying trends in emissions and associated uncertainties for the period 1990–1999. As per the UNFCCC reporting guidelines, relevant Common Reporting Format (CRF) Tables, Summary Report for CO_2 Equivalent Emissions and Emissions Trends (All Gases) have been provided in Annex 2 at the end of this chapter.

INTRODUCTION

On behalf of the Government of Canada, Environment Canada develops and publishes annually Canada's Greenhouse Gas Inventory (CGHGI). The GHGs whose emissions have been estimated in the national inventory are:

- carbon dioxide (CO_2);
- methane (CH_4);
- nitrous oxide (N_2O);
- sulphur hexafluoride (SF_6);
- perfluorocarbons (PFCs); and
- hydrofluorocarbons (HFCs).

The inventory reporting format is based on international reporting methods agreed to by the UNFCCC according to the Intergovernmental Panel on Climate Change (IPCC) procedures in its Guidelines for National Greenhouse Gas Inventories (IPCC, 1997). The inventory uses an internationally agreed upon reporting format that groups emissions into the following six sectors: energy, industrial processes, solvent and other product use, agriculture, land use change and forestry, and waste. Each of these categories is further subdivided within the inventory and follows, as closely as possible, the UNFCCC sector and subsector divisions.[9] A brief description of the types of methodologies used to estimate trends in emissions is provided in Annex 1 at the end of this chapter.

CANADA'S 1999 GREENHOUSE GAS INVENTORY

In 1999, Canadians contributed about 699 megatonnes of carbon dioxide equivalent (Mt CO_2 eq.)[10] GHG emissions to the atmosphere. (Note: In this chapter, GHG emissions are presented in units of Mt. Unless explicitly stated otherwise, all emissions estimates given in Mt represent emissions of GHG in Mt CO_2 eq.) Canada's annual emissions are 2.2% of total global GHG emissions. On a per capita basis, Canada ranks ninth in the world (second in the G8) for carbon dioxide emissions due to a variety of factors, in particular its energy-intensive economy.

Approximately 73% of total GHG emissions in 1999 resulted from the combustion of fossil fuels. A sectoral breakdown of Canada's total emissions[11] for 1999 (Figure 3.1) is as follows:

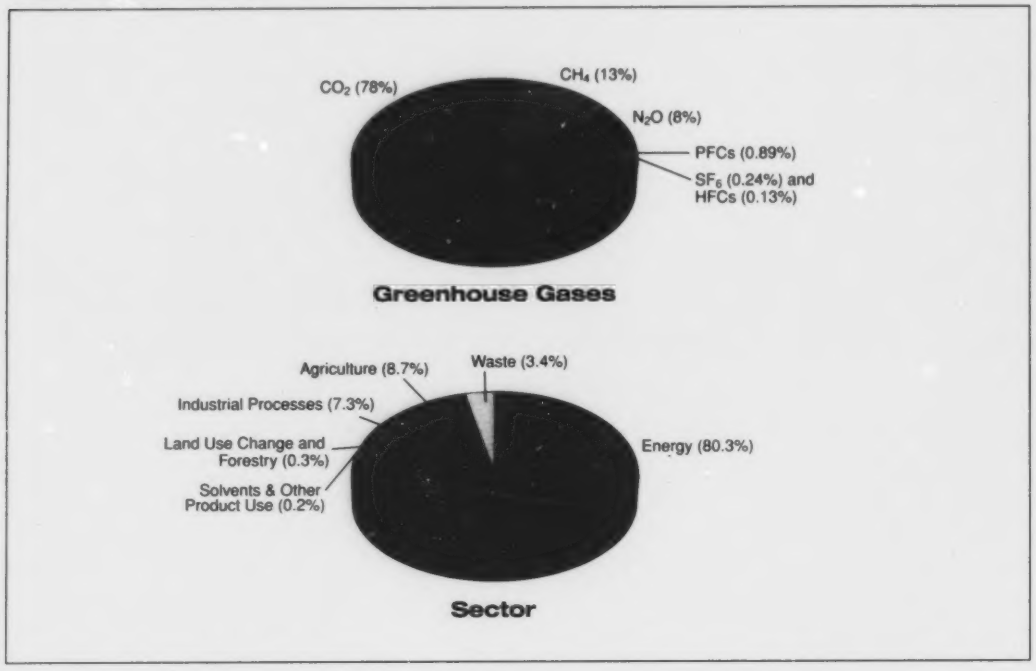
- energy, 80.3%;
- industrial processes, 7.3%;
- solvent and other product use, 0.2%;
- agriculture, 8.7%;

9 Minor differences between UNFCCC and CGHGI sector designations have been provided in more detail in Environment Canada (2001).

10 Each of the GHGs has a unique average atmospheric lifetime over which it is an effective climate-forcing agent. Global warming potential (GWP)–indexed multipliers have been established to calculate a longevity equivalency with carbon dioxide taken as unity. Typical GWP multipliers range from 21 for methane to 23 900 for sulphur hexafluoride. By applying unique GWP multipliers to the annual emissions of each gas, an annual CO_2 equivalency may be summed that represents the total GWP of all climate-forcing gases considered.

11 Due to rounding, individual percentages may not add up to 100%.

Figure 3.1 Canada's GHG Emissions by Gas and Sector, 1999



- land use change and forestry, 0.3%; and
- waste, 3.4%.

On a GHG basis, carbon dioxide contributed the largest share of 1999 emissions at 78.1% (about 546 Mt), while methane accounted for 12.9% (90 Mt). Nitrous oxide supplied 7.7% of the emissions (54 Mt), PFCs supplied 0.89% (6 Mt), and sulphur hexafluoride and HFCs constituted the remainder (Figure 3.1).

Net carbon dioxide removals associated with the managed land use change and forestry sector are not included in the inventory totals; however, they are estimated to be less than -20 Mt CO_2[12] for 1999. Table 3.1 summarizes total GHG emissions and removals by sector and gas for 1999. A complete summary of emissions and their associated methodologies for the period 1990–1999 can be found in Environment Canada's publication entitled Canada's Greenhouse Gas Inventory 1990–1999: Emission and Removal Estimation Practices and Methods (Environment Canada, 2001).

CANADA'S GREENHOUSE GAS TRENDS, 1990-1999

The 1999 data on Canada's GHG emissions demonstrate progress in reducing emissions in some areas of the economy, but also indicate where more work needs to be done. Total emissions of all GHGs in 1999 were 699 Mt, 15.1% above the 1990 level of 607 Mt. Although emissions have been rising since 1990, the upward trend is slowing (Figure 3.2). For example, in 1994, emissions growth peaked at over 3.5% per year, while in 1998–1999, the annual emissions increase was only 1.4%. The accumulative average annual growth of emissions over the 1990–1999 period was 1.7%.

Canadian emissions in 1999 increased by 9.5 Mt over the 1998 level of 689 Mt. The energy sector was responsible for the majority of the short-term increase, with emissions rising almost 12 Mt. For example, GHG emissions associated with vehicles in 1999 rose by 5.1 Mt over 1998, an increase of 3%. Increasing discharges from light-duty trucks and heavy-duty vehicles

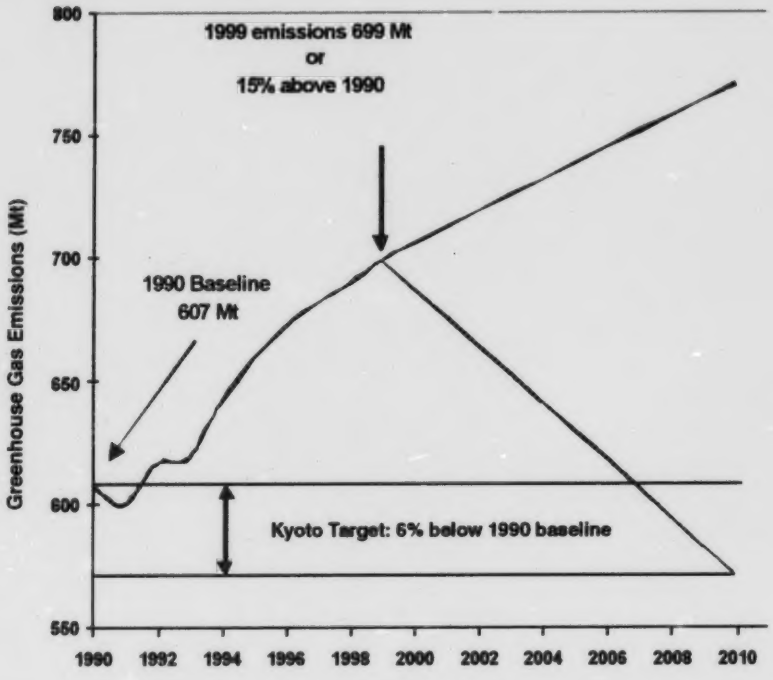
12 Removals of carbon dioxide are shown as negative values.

Table 3.1 Canada's GHG Emissions Summary by Sector and Gas, 1999

GHG Source and Sink Category Global Warming Potential Multiplier	CO_2 1 kt	CH_4 kt	CH_4 21 kt CO_2 eq	N_2O kt	N_2O 310 kt CO_2 eq	HFCs 140-11 700 kt CO_2 eq	PFCs 6 500-9 200 kt CO_2 eq	SF_6 23 900 kt CO_2 eq	Total kt CO_2 eq
ENERGY									
FUEL COMBUSTION									
Fossil Fuel Industries	62 300	110	2 400	1.3	410				65 100
Electricity & Heat Generation	118 000	3.5	74	2.2	680				119 000
Mining	7 620	0.2	3.2	0.2	55				7 680
Manufacturing	51 400	1.7	36	1.2	360				51 700
Construction	1 160	0.0	0.4	0.0	10				1 170
Transport									
Light Duty Gasoline Vehicles	47 500	5.1	110	7.8	2 400				50 000
Light Duty Gasoline Trucks	31 900	4.5	94	8.8	2 700				34 700
Heavy Duty Gasoline Vehicles	5 610	0.8	17	0.8	260				5 880
Motorcycles	232	0.2	3.9	0.0	1.4				237
Off Road Gasoline	5 290	6.0	130	0.1	35				5 450
Light Duty Diesel Vehicles	563	0.0	0.3	0.0	13				576
Light Duty Diesel Trucks	394	0.0	0.2	0.0	8.9				403
Heavy Duty Diesel Vehicles	36 500	1.8	38	1.1	330				36 900
Off Road Diesel	14 000	0.7	15	5.6	1 700				15 700
Propane & Natural Gas Vehicles	1 470	1.9	40	0.0	9.0				1 520
Domestic Aviation	13 200	0.6	13	1.3	400				13 600
Domestic Marine	4 830	0.4	7.5	1.0	320				5 160
Railways	5 780	0.3	6.7	2.3	720				6 510
Vehicles Subtotal	**167 000**	**22**	**470**	**29**	**9 000**				**177 000**
Pipelines	12 200	12	260	0.3	100				12 600
Transport Subtotal	**179 000**	**35**	**730**	**29**	**9 100**				**189 000**
Residential	40 500	95	2 000	1.7	520				43 000
Commercial & Institutional	28 700	0.5	11	0.6	190				28 900
Other	2 670	0.0	0.8	0.1	18				2 690
COMBUSTION SUBTOTAL	**491 000**	**250**	**5 200**	**37**	**11 000**				**508 000**
FUGITIVE									
Solid Fuels (i.e. Coal Mining)		51	1 100						1 100
Oil & Gas	14 000	1 800	37 000						52 000
FUGITIVE SUBTOTAL	**14 000**	**1 800**	**38 000**	**0.0**	**0.0**				**53 000**
ENERGY TOTAL	**506 000**	**2 100**	**44 000**	**37**	**11 000**				**561 000**
INDUSTRIAL PROCESSES									
Non Metallic Mineral Production	8 670								8 670
Ammonia, Adipic Acid & Nitric Acid Production	4 050			8.2	2 500				6 600
Ferrous Metal Production	8 500								8 500
Aluminum & Magnesium Production	3 920						6 000	1 700	12 000
Other & Undifferentiated Production	14 000								14 000
INDUSTRIAL PROCESSES TOTAL	**39 000**			**8.2**	**2 500**		**6 000**	**1 700**	**50 000**
SOLVENT & OTHER PRODUCT USE				**1.5**	**460**	**900**	**20**		**1 000**
AGRICULTURE									
Enteric Fermentation		850	18 000						18 000
Manure Management		240	5 100	14	4 300				9 400
Agricultural Soils**	200			100	30 000				30 000
AGRICULTURE TOTAL	**200**	**1 100**	**23 000**	**120**	**38 000**				**61 000**
LAND USE CHANGE & FORESTRY *		**60**	**1 000**	**4**	**1 000**				**2 000**
WASTE									
Solid Waste Disposal on Land		1 000	22 000						22 000
Wastewater Handling		19	400	3.1	950				1 300
Waste Incineration	280	0.3	6.9	0.2	59				350
WASTE TOTAL	**280**	**1 100**	**22 000**	**3.3**	**1 000**				**24 000**
TOTAL	**546 000**	**4 300**	**90 000**	**170**	**54 000**	**900**	**6 000**	**1 700**	**699 000**
CO_2 from Land Use Change & Forestry** (20 000)									

Notes:
Due to rounding, individual values may not add up to totals (zero values may represent estimated quantities too small to display).
** Only one significant figure shown due to high uncertainty.
* Methane and Nitrous Oxide emissions from prescribed fires and anthropogenic fires outside the Wood Production Forest. Fires located in National Parks are not included in the provincial/territorial total but are reported in the national total.

Figure 3.2 Canada's GHG Emissions Trend and Forecast, 1990–2010



(Sources: Actual Emission Estimates, Baseline – Environment Canada, 2000; Forecast – NRCan, 2001).
See "Canada's Greenhouse Gas Inventory 1990–1999", Environment Canada, April 2001.

contributed to the growth. These trends reflect the growing numbers of sport utility vehicles (SUVs) and greater freight trucking activity. The 2.2% short-term increase in energy-related emissions was partially offset by emissions reductions of 2.2 Mt from the industrial processes sector.

Table 3.2 summarizes Canada's GHG emissions by sector for the years 1990–1999. A series of fact sheets, providing detailed analyses of Canada's GHG emissions and removal trends between 1990 and 1999, is currently in preparation by Environment Canada.

Table 3.3 depicts Canada's total GHG emissions from 1990 to 1999, along with several primary indicators: gross domestic product (GDP), population, energy use, energy production, and energy export. From the table, it is evident that the 15.1% increase in GHG emissions during the past decade outpaced increases in both population (which grew 10%) and energy use (which rose 13%). However, the growth in total emissions was well short of the almost 25% growth in GDP between 1990 and 1999 (Statistics Canada, 1999a). On average, GDP grew at about 3% per year in the mid-1990s and by 4.5% in 1999.

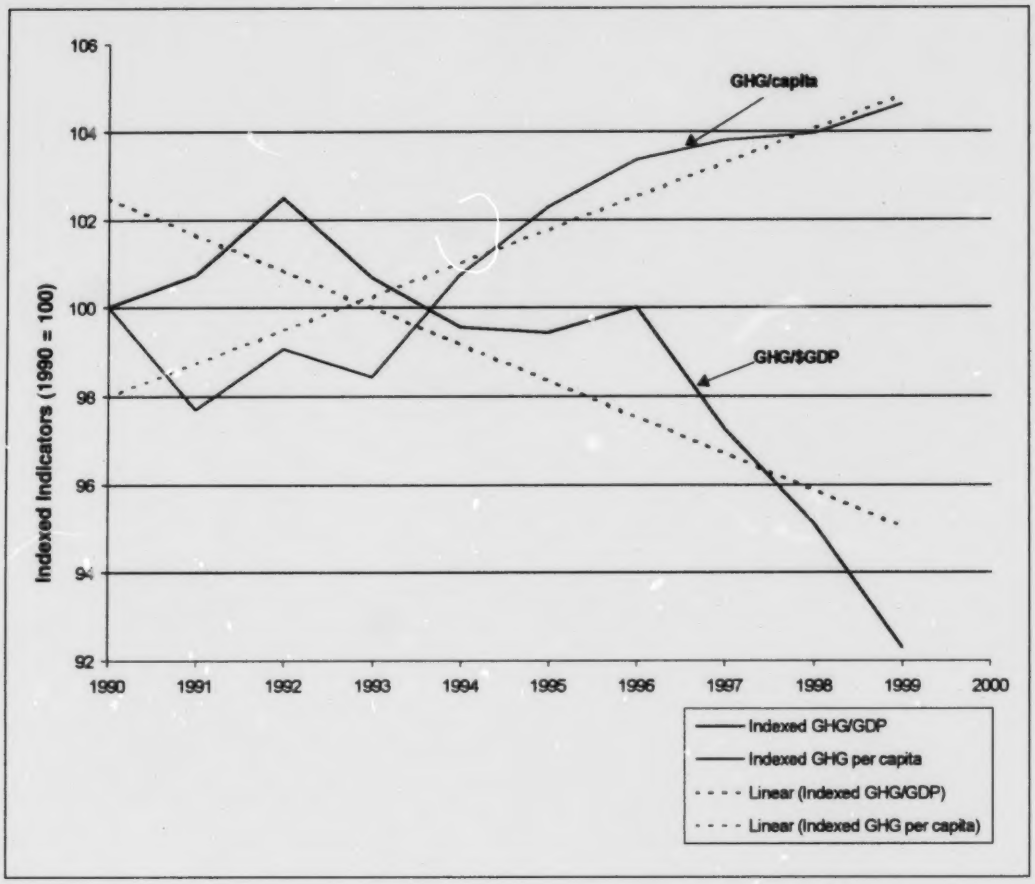
GHG emissions per unit of GDP decreased over the period 1990–1999, mainly due to a switch away from fossil fuels in the industrial, residential, and commercial sectors and to gains in energy efficiency (Figure 3.3). Growth in total emissions, having outstripped growth in population, was influenced by changing characteristics in various sectors. Examples include shifts in electrical generation in Ontario from nuclear to coal, expanded coal thermal

Table 3.2 Canada's GHG Emissions Summary by Sector, 1990–1999

Sources and Sinks Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					kt CO_2 eq. All Gases					
ENERGY										
FUEL COMBUSTION										
Fossil Fuel Industries	51500	49500	52100	52600	53300	54700	55300	51000	56500	65100
Electricity & Heat Generation	95300	96700	103000	93800	96000	101000	99700	111000	124000	119000
Mining	6190	5030	4790	7370	7490	7860	8740	8970	8020	7680
Manufacturing	54500	52100	51500	49100	52200	52900	54700	54600	52400	51700
Construction	1880	1630	1750	1390	1400	1180	1270	1260	1120	1170
Transport										
Light Duty Gasoline Vehicles	53700	51200	51600	51800	52300	51300	49900	50000	49700	50000
Light Duty Gasoline Trucks	21700	22200	24000	25600	27400	28500	29900	32000	32800	34700
Heavy Duty Gasoline Vehicles	3140	3320	3730	4070	4480	4760	4980	5050	5490	5880
Motorcycles	230	220	218	219	221	214	210	221	232	237
Off Road Gasoline	5010	4550	3640	3850	3930	3940	4680	4310	5840	5450
Light Duty Diesel Vehicles	672	633	631	624	617	594	602	600	597	576
Light Duty Diesel Trucks	591	507	456	429	432	416	402	505	455	403
Heavy Duty Diesel Vehicles	24600	23900	24300	25700	28500	30800	32500	35500	35600	36900
Off Road Diesel	11300	9960	9480	10900	12000	12700	13200	14100	14800	15700
Propane & Natural Gas Vehicles	2210	2320	2680	2030	1920	2100	1980	1840	1780	1520
Domestic Aviation	10700	9530	9720	9410	10100	10900	11900	12400	13000	13600
Domestic Marine	5050	5250	5100	4480	4660	4380	4470	4530	5150	5160
Railways	7110	6590	6890	6860	7100	6430	6290	6380	6140	6510
Vehicles Subtotal	**146000**	**140000**	**143000**	**146000**	**154000**	**157000**	**161000**	**168000**	**171000**	**177000**
Pipelines	6900	7640	9890	10400	10800	12000	12500	12500	12500	12600
Transport Subtotal	**153000**	**148000**	**152000**	**156000**	**164000**	**169000**	**173000**	**180000**	**184000**	**189000**
Residential	44000	42300	43500	45500	46300	44900	49700	46400	41000	43000
Commercial & Institutional	25800	26500	27000	28100	27400	29000	29600	30000	27200	28900
Other	2420	2760	3270	3060	2560	2790	2950	2940	2610	2690
COMBUSTION SUBTOTAL	**434000**	**424000**	**439000**	**437000**	**451000**	**463000**	**475000**	**487000**	**496000**	**508000**
FUGITIVE										
Solid Fuels (i.e. Coal Mining)	1900	2100	1800	1800	1800	1700	1800	1600	1400	1100
Oil & Gas	36000	38000	41000	43000	45000	48000	51000	51000	51000	52000
FUGITIVE SUBTOTAL	**38000**	**40000**	**42000**	**44000**	**47000**	**50000**	**53000**	**53000**	**52000**	**53000**
ENERGY TOTAL	**472000**	**464000**	**482000**	**482000**	**498000**	**513000**	**528000**	**539000**	**549000**	**561000**
INDUSTRIAL PROCESSES										
Non Metallic Mineral Production	8160	6980	6640	6880	7510	7690	8030	8180	8370	8670
Ammonia, Adipic Acid & Nitric Acid Production	15000	14000	14000	13000	15000	16000	16000	15000	9700	6600
Ferrous Metal Production	7590	8900	9080	8760	8090	8440	8290	8100	8320	8500
Aluminum & Magnesium Production	11000	13000	12000	13000	13000	11000	11000	11000	11000	12000
Other & Undifferentiated Production	11000	11000	11000	12000	13000	13000	14000	14000	14000	14000
INDUSTRIAL PROCESSES TOTAL	**53000**	**54000**	**53000**	**54000**	**56000**	**56000**	**57000**	**56000**	**52000**	**50000**
SOLVENT & OTHER PRODUCT USE	**400**	**400**	**400**	**400**	**400**	**900**	**1000**	**1000**	**1000**	**1000**
AGRICULTURE										
Enteric Fermentation	16000	16000	17000	17000	18000	18000	18000	18000	18000	18000
Manure Management	8300	8300	8500	8500	8900	9200	9300	9300	9400	9400
Agricultural Soils**	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
AGRICULTURE TOTAL	**59000**	**58000**	**58000**	**58000**	**60000**	**61000**	**61000**	**61000**	**61000**	**61000**
LAND USE CHANGE & FORESTRY*	**2000**	**3000**	**3000**	**3000**	**4000**	**5000**	**2000**	**900**	**3000**	**2000**
WASTE										
Solid Waste Disposal on Land	19000	19000	20000	20000	20000	20000	20000	21000	21000	22000
Wastewater Handling	1200	1200	1300	1300	1300	1300	1300	1300	1300	1300
Waste Incineration	320	320	330	330	330	330	340	340	340	350
WASTE TOTAL	**20000**	**21000**	**21000**	**22000**	**22000**	**22000**	**22000**	**23000**	**23000**	**24000**
TOTAL	**607000**	**600000**	**616000**	**619000**	**641000**	**658000**	**672000**	**682000**	**689000**	**699000**
CO_2 from Land Use Change & Forestry**	-70000	-70000	-50000	-40000	-40000	-20000	-30000	-20000	-20000	-20000

Notes:
Due to rounding, individual values may not add up to totals (zero values may represent estimated quantities too small to display)
** Only one significant figure shown due to high uncertainty.
* Methane and Nitrous Oxide emissions from prescribed fires and anthropogenic fires outside the Wood Production Forest. Fires located in National Parks are not included in the provincial/territorial total but are reported in the national total.

Figure 3.3 Trends in GHG Intensity of GDP and Population, 1990–1999



generation in at least four provinces, increased road freight transport, and increased fossil fuel extraction for export.

Overall, the energy sector is responsible for 96.6% of the 91.4 Mt increase in total Canadian GHG emissions over the period 1990–1999, while representing 80.3% of the total GHG emissions for 1999. The greatest contributors to the increases in GHG emissions are:

- vehicles, 30.6 Mt (21.0% increase);
- electricity and steam generation, 23.2 Mt (24.3% increase); and
- fossil fuel industries, 13.6 Mt (26.4% increase).

The GHG emissions increase associated with the transport sector has been driven by increases in trucking activity and the number of SUVs and vans. For example, emissions from light-duty trucks, which include pickup trucks, SUVs, and vans, have increased by 57% since 1990, while emissions from cars have decreased 7%. On average, light-duty trucks emit 40% more GHGs per kilometre than cars.

Growth in oil and gas exports, primarily to the United States, contributed significantly to emissions growth [13] between 1990 and 1999

13 All export data refer to net exports (i.e., gross exports less imports). The source for all export and production data is Environment Canada (2000).

Table 3.3 Canada's GHG Emissions and Accompanying Variables, 1990–1999

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total GHG (Mt)	607	600	616	619	641	658	672	682	689	699
Growth Since 1990	*N/A*	*-1.2%*	*1.5%*	*2.0%*	*5.6%*	*8.4%*	*10.7%*	*12.4%*	*13.5%*	*15.2%*
GDP - Expense (Millions of 1992$)	705 464	692 247	698 544	714 583	748 350	769 082	780 916	815 013	842 002	880 254
Growth Since 1990	*N/A*	*-1.9%*	*-1.0%*	*1.3%*	*6.1%*	*9.0%*	*10.7%*	*15.5%*	*19.4%*	*24.8%*
Population (000s)	27 701	28 031	28 377	28 703	29 036	29 354	29 672	29 987	30 247	30 491
Growth Since 1990	*N/A*	*1.2%*	*2.4%*	*3.6%*	*4.8%*	*6.0%*	*7.1%*	*8.3%*	*9.2%*	*10.1%*
Energy Use (PJ)	9 230	9 091	9 176	9 314	9 564	9 695	10 097	10 200	10 137	10 459
Growth Since 1990	*N/A*	*-2%*	*-1%*	*1%*	*4%*	*5%*	*9%*	*11%*	*10%*	*13%*
Energy Produced (PJ)	7 752	7 954	8 553	9 192	9 839	10 277	10 607	10 892	11 365	11 296
Growth Since 1990	*N/A*	*3%*	*10%*	*19%*	*27%*	*33%*	*37%*	*41%*	*47%*	*46%*
Energy Exported (PJ)	1 754	2 265	2 856	3 083	3 510	4 030	3 983	4 082	4 615	4 545
Growth Since 1990	*N/A*	*29%*	*63%*	*76%*	*100%*	*130%*	*137%*	*133%*	*163%*	*159%*
Emissions Associated with Exports (Mt)	21.5	25.7	30.4	30.3	36.4	42.9	40.7	41.6	46.9	45.4
Growth Since 1990	*N/A*	*20%*	*41%*	*41%*	*69%*	*100%*	*89%*	*93%*	*118%*	*111%*

Table 3.4 Crude Oil: Production, Net Export, and GHG Emissions Trends, 1990–1999

Crude Oil	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Production (PJ)	3 568	3 548	3 689	3 844	4 008	4 148	4 263	4 483	4 691	4 443
Growth Since 1990	*N/A*	*-0.6%*	*3.4%*	*7.8%*	*12.3%*	*16.3%*	*19.5%*	*25.6%*	*31.5%*	*24.5%*
Net Export (PJ)	241	473	726	719	797	1 045	977	1 013	1 260	955
Growth Since 1990	*N/A*	*96.4%*	*201.1%*	*198.2%*	*230.7%*	*333.4%*	*305.5%*	*320.1%*	*422.5%*	*295.9%*
Emissions Associated with Exports (Mt CO_2 eq.)	9	11	13	11	14	18	16	16	19	16
Growth Since 1990	*N/A*	*22.7%*	*48.9%*	*27.3%*	*62.5%*	*102.3%*	*82.0%*	*85.8%*	*116.7%*	*77.9%*

Table 3.5 Natural Gas: Production, Net Export, and GHG Emissions Trends, 1990–1999

Natural Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Production (PJ)	4 184	4 406	4 864	5 348	5 831	6 129	6 343	6 409	6 674	6 853
Growth Since 1990	*N/A*	*5.3%*	*16.3%*	*27.8%*	*39.9%*	*46.5%*	*51.6%*	*53.2%*	*59.5%*	*63.8%*
Net Export (PJ)	1 513	1 792	2 130	2 364	2 713	2 985	3 006	3 070	3 356	3 590
Growth Since 1990	*N/A*	*18.4%*	*40.8%*	*56.3%*	*79.3%*	*97.3%*	*98.7%*	*102.9%*	*121.8%*	*137.3%*
Emissions (Mt CO_2 eq.)	13	15	17	19	22	25	25	25	28	30
Growth Since 1990	*N/A*	*17.3%*	*36.2%*	*50.4%*	*74.0%*	*97.6%*	*94.6%*	*98.6%*	*118.9%*	*134.3%*

(Tables 3.4 and 3.5). In this period, net oil exports grew by 296% to 955 PJ (nearly 12 times the growth rate of oil production), while net exports of gas increased 137% to 3590 PJ (twice the growth rate of gas production). The proportion of emissions from all oil and gas production and processing activities that is attributable to exports increased from 22 Mt in 1990 to over 5 Mt in 1999.[14] Overall, total energy exported has increased 159% between 1990 and 1999, while emissions associated with exports have increased 111%.

There have also been reductions in GHG emissions in certain sectors in Canada over the period 1990–1999. For example, emissions from energy consumption in manufacturing dropped by 2.7 Mt, even though the sector grew 32% during this period. This decrease has occurred primarily because of improved energy efficiency

14 Absolute emissions attributable to net exports are rough approximations. The long-term trends are considered more accurate

within the advanced products and services industries (such as electronic, automotive, and aerospace) and other manufacturing industries. Also, industrial process emissions from the production of adipic acid during the manufacture of nylon have dropped considerably since 1996, due to process improvements. Averaged over 1990–1999, emissions in this subsector have been reduced by 56%.

GREENHOUSE GAS TRENDS BY UNFCCC SECTOR, 1990–1999

Energy Sector (1999 GHG emissions, 561 Mt)

Energy-related activities are by far the largest source of GHG emissions in Canada. The energy sector includes emissions of all GHGs from the production of fuels and their combustion for the primary purpose of delivering energy. Emissions in this sector are classified as either *fuel combustion* or *fugitive releases*. Fugitive emissions are defined as intentional or unintentional releases of GHGs from the production, processing, transmission, storage, and delivery of fossil fuels.

Overall, fuel combustion and fugitive emissions accounted for 80.3% of total Canadian GHG emissions in 1999 (508 Mt and 53 Mt, respectively). Between 1990 and 1999, fuel combustion–related emissions increased 16.9%, while emissions from fugitive release rose 39.1%. Annual changes in both fuel combustion and fugitive emissions through the period 1990–1999 are shown in Table 3.6.

On a per gas basis for the energy sector, carbon dioxide accounted for the majority of emissions in 1999 (506 Mt), while methane contributed 44 Mt and nitrous oxide accounted for 11 Mt. The largest contributor to emissions in the energy sector is the transport sector, which accounted for 33.7% of energy emissions, with emissions from the energy industries sector close behind with 32.7% of energy-related emissions.

Emissions from Fuel Combustion

Emissions of GHGs from fuel combustion rose from 434 Mt in 1990 to 508 Mt in 1999, a 16.9% increase. Fuel combustion emissions are divided into the following UNFCCC categories: *energy industries*,[15] *manufacturing industries and construction*, *transport*, and *other sectors*. The other sectors category comprises emissions from the residential and commercial subsectors, as well as minor contributions of stationary fuel combustion emissions from agriculture and forestry.

Table 3.6 shows the changes in the emissions of each sector in the fuel combustion category. The sector in which emissions have increased the most since 1990 is energy industries (25.1% growth in GHG), while the transport sector produced the largest amount of emissions within the energy category for 1999, at 189 Mt. Emissions from other sectors (the main contributors being residential and commercial subsector emissions) increased 3.3% between 1990 and 1999, whereas emissions from the manufacturing industries and construction sector decreased 3.1%. A more comprehensive account of the changes in emissions is presented in the individual sectoral sections of the energy category within this chapter.

1. Energy Industries (1999 GHG emissions, 184 Mt)

The energy industries sector is the second largest source of fuel combustion emissions and accounts for 26.3% of Canada's total GHG emissions. Fuel combustion emissions included in this sector are from stationary sources only, from the production, processing, and refining of energy (electricity generation, oil and natural gas production, refining of petroleum products, etc.). In 1999, emissions from this sector totalled 184 Mt, an increase of 25.1% from the 1990 level of 147 Mt. UNFCCC subcategories within this sector include public electricity and heat production, petroleum refining, and manufacture of solid fuels and other energy industries.

i) Public Electricity and Heat Production[16]

This sector accounted for 16.9% (119 Mt) of Canada's 1999 GHG emissions and was responsible for 25% of the total emissions growth between 1990 and 1999. Overall, emissions have

15 The UNFCCC energy industries sector is composed of the following CGHGI sectors: *fossil fuel industries* and *electricity and heat generation*.

16 The public electricity and heat production sector includes emissions from public utilities and industrial generation.

Table 3.6 Energy GHG Emissions by UNFCCC Sector, 1990–1999

Greenhouse Gas Sources/Sinks	Mt CO_2 Equivalent									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy	**472**	**464**	**482**	**482**	**498**	**513**	**528**	**539**	**549**	**561**
A. Fuel Combustion (Sectoral Approach)	**434**	**424**	**439**	**437**	**451**	**463**	**475**	**487**	**496**	**508**
1. Energy Industries	147	146	155	146	149	156	155	162	180	184
2. Manufacturing Industries and Construction	62.6	58.7	58	57.8	61.1	62	64.7	64.8	61.6	60.6
3. Transport	153	148	152	156	164	169	173	180	184	189
4. Other Sectors	72.2	71.5	73.8	76.7	76.3	76.7	82.2	79.3	70.8	74.6
B. Fugitive Emissions from Fuels	**38**	**40**	**42**	**44**	**47**	**50**	**53**	**53**	**52**	**53**
1. Solid Fuels	1.9	2.1	1.8	1.8	1.8	1.7	1.8	1.6	1.4	1.1
2. Oil and Natural Gas	36	38	41	43	45	48	51	51	51	52

Table 3.7 GHG Emissions from Electricity and Heat Generation, 1990–1999

Electricity Generation Source Emissions	Mt CO_2 Equivalent										% of 1999 Electricity Generation
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
Coal	78.8	82.5	85.4	78.0	81.3	82.3	84.0	90.4	96.5	94.7	81.6%
Oil	11.4	9.6	10.5	7.8	6.0	7.0	5.6	8.6	12.4	10.0	8.6%
Natural Gas	4.0	3.5	5.9	6.9	7.0	9.2	7.8	9.7	11.8	10.8	9.3%
Emissions from Other Sources	0.4	0.4	0.5	0.5	0.6	0.5	0.3	0.5	0.6	0.6	0.5%

Table 3.8 GHG Emissions from Petroleum Refining and Manufacture of Solid Fuels and Other Energy Industries, 1990–1999

GHG Source Category	Mt CO_2 Equivalent		Percent Change
	1990	1999	1990–1999
Petroleum Refining	26.1	27.4	5.1%
Manufacture of Solid Fuels and Other Energy Industries	25.4	37.7	48.4%
TOTAL	**51.5**	**65.1**	**26.4%**

increased over 24% (down from being 28% higher in 1998), or 23 Mt, since 1990.

Hydroelectric and coal-fired generation continue to be the major sources of Canadian electricity, accounting for 55% and 18%, respectively, of total national generation in 1999. Nuclear energy provided 12%, natural gas nearly 4%, oil 2%, and industrial sources almost 9%. Total annual production increased over 19% between 1990 and 1999. This rate of growth exceeds the population growth rate of 10% for the same period, pointing to a rapid increase in per capita demand over the period.

In 1999, the dominant proportion of GHG emissions, nearly 82%, was from the use of coal (which has much higher emissions than natural gas), while natural gas and oil accounted for 9.3% and 8.6%, respectively (Table 3.7). The higher GHG intensity of coal is reflected in the fact that it accounted for only 18% of the total electricity generated in Canada in 1999.

The growth in emissions is directly related to rising demand for power and the increasing use of fossil fuels in the generation mix. While increasing use of natural gas has helped mitigate the rate of emissions growth, the trend away from non-emitting sources (nuclear and hydro) in the

latter part of the decade has resulted in large absolute increases.

Contributions from both nuclear and hydro declined in the latter part of the 1990s when nuclear facilities in Ontario were decommissioned for maintenance and rehabilitation. Although hydroelectric generation increased nearly 18% from 1990 to 1999, production was reduced substantially in 1997 and 1998 due to low reservoir levels (Statistics Canada, 1998). Although imports increased to meet the supply/demand gap, growth in demand was largely met by domestic generation from fossil fuels, primarily coal and natural gas. Coal-fired generation increased 27%, while natural gas production increased more than 387% between 1990 and 1999.

ii) Petroleum Refining and Manufacture of Solid Fuels and Other Energy Industries[17]

The petroleum refining sector includes emissions from the combustion of fossil fuels during the production of refined petroleum products. The manufacture of solid fuels and other energy industries sector encompasses fuel combustion emissions associated with the upstream oil and gas industry (including upgrading of bitumen to synthetic crude oil). As shown in Table 3.8, between 1990 and 1999, emissions from the petroleum refining sector increased 5.1% (from 26.1 to 27.4 Mt), while emissions from the manufacture of solid fuels and other energy industries sector rose to 37.7 Mt, 48.4% higher than the 1990 level of 25.4 Mt. The combined effect for the two sectors is an increase of 26.4%; this growth is due to increases in oil and natural gas production, largely for export.

2. Manufacturing Industries and Construction (1999 GHG emissions, 60.6 Mt)

Emissions from the manufacturing industries and construction sector include the combustion of fossil fuels by all manufacturing industries and the construction industry.[18] In 1999, GHG emissions were 60.6 Mt, a reduction of 3.1% from the 1990 level of 62.6 Mt. Over the short term (1998–1999), emissions dropped by 1.9%. Overall, this sector was responsible for 8.7% of Canada's total GHG emissions for 1999. Figure 3.4 provides an overview of the changes in emissions for the various manufacturing industries and construction between 1990 and 1999.

The overall reduction in emissions in the manufacturing sector coincides with an increase in GDP (sector specific) of 32% between 1990 and 1999 (Statistics Canada, 1999a). The decline in emissions in the sector is largely due to significant fuel substitution away from high-GHG-intensity fuels (heavy fuel oil, diesel, and coal) to lower-GHG-intensity fuels (natural gas, electricity, biomass) within the advanced products and services industries (such as electronics, automotive, and aerospace), a rapidly growing sector of the Canadian economy, and other industries.

3. Transport (1999 GHG emissions, 189 Mt)

Transport is a large and diverse sector accounting for 27.1% of Canada's GHG emissions in 1999. The sector includes the emissions from fuel combustion for the transport of passengers and freight in six distinct subcategories:

- road transport;
- aviation;
- marine;
- rail;
- off-road ground transport (e.g., construction or agriculture vehicles); and
- pipelines (pipelines, both oil and gas, represent non-vehicular transport).

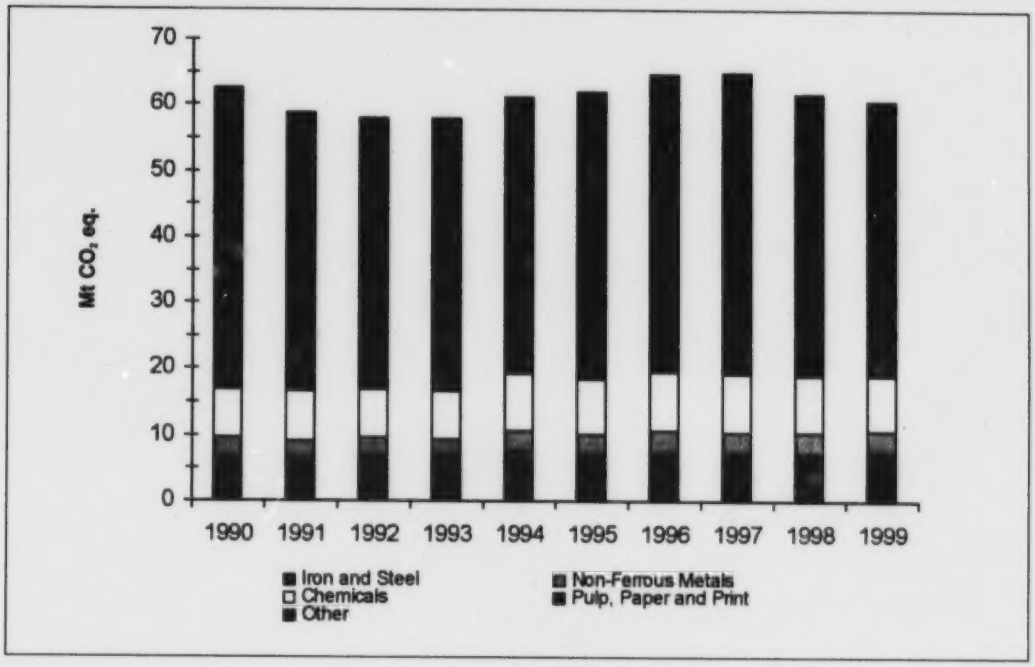
From 1990 to 1999, GHG emissions from transport, driven primarily by energy used for freight transport, rose 23.7%, or 36.3 Mt. Overall, transport was the leading sector in 1999 for GHG emissions, contributing 189 Mt and accounting for nearly 40% of Canada's emissions growth from 1990 to 1999.

Emissions from light-duty gasoline trucks (LDGT), the subcategory that includes SUVs and

17 In CGHGI, the fossil fuel industries category encompasses both the *petroleum refining* and *manufacture of solid fuels and other energy* subsectors.

18 The CGHGI categories that constitute this UNFCCC sector are manufacturing, construction, and mining (refer to Tables 3.1 and 3.2).

Figure 3.4 GHG Emissions from Manufacturing Industries and Construction, 1990-1999



vans, have increased 59.6% since 1990 (from 21.7 Mt in 1990 to 34.7 Mt in 1999), while emissions from cars (light-duty gasoline vehicles or LDGV) have decreased 6.9% (from 53.7 Mt in 1990 to 50.0 Mt in 1999) (Table 3.9).

The growth in transport sector emissions may be due not only to the 12% increase in the total vehicle fleet, but also to a shift in light-duty vehicle purchases from cars (LDGV) to trucks (LDGT), which, on average, emit 40% more GHGs per kilometre than cars.

Over the period 1990–1999, the increase of 13.0 Mt and 12.3 Mt for LDGT and heavy-duty diesel vehicles (HDDV), respectively, indicates the trend toward increasing use of SUVs and heavy-duty trucks for transport (Figure 3.5).

In 1999, emissions from HDDVs contributed 36.9 Mt to Canada's total GHG emissions (an increase of 50.2% from 1990 emissions). Although emissions from heavy-duty gasoline vehicles (HDGV) were substantially lower, at 5.9 Mt for 1999, this subcategory exhibited an increase of 87.6% over the same period. While there are difficulties in obtaining accurate and complete data for the freight transport mode, the trends in data from major for-hire truck haulers in Canada show conclusively that freight hauling by truck has increased substantially and that this activity is the primary task performed by HDGVs and HDDVs.

Many factors affect transport mode choices. For road transport, fuel cost is one of the most influential. Real-cost analysis (in 1998 dollars) of both gasoline and diesel showed a declining price from 1990 to 1998 when adjusted according to the Consumer Price Index (Natural Resources Canada on-line pricing data sheets [e.g., http://nrn1.nrcan.gc.ca/es/erb/od/pips/31486.pdf]; M. Monaghan, pers. comm.). This decline may be partly responsible for the rapid shift in modes to bulkier, less efficient vehicles, such as vans and SUVs, and to increased use of vehicles (vehicle-kilometres travelled).

Table 3.9 GHG Emissions from Transport, 1990–1999

		kt CO_2 Equivalent									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Automobiles	LDGV	53.7	52.1	51.6	51.8	52.3	51.3	49.9	50.0	49.7	50.0
	LDDV	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Alternative Fuels	2.2	2.3	2.7	2.0	1.9	2.1	2.0	1.8	1.8	1.5
Heavy-Duty Vehicles	HDGV	3.1	3.3	3.7	4.1	4.5	4.8	5.0	5.1	5.5	5.9
	HDDV	24.6	23.9	24.3	25.7	28.5	30.8	32.5	35.5	35.6	36.9
Light-Duty Trucks	LDGT	21.7	22.2	24.0	25.6	27.4	28.5	29.9	32.0	32.8	34.7
	LDDT	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.4
Other Transport	Air	10.7	9.5	9.7	9.4	10.1	10.9	11.9	12.4	13.0	13.6
	Marine	5.0	5.2	5.1	4.5	4.7	4.4	4.5	4.5	5.1	5.2
	Rail	7.1	6.6	6.9	6.9	7.1	6.4	6.3	6.4	6.1	6.5
	Motorcycles	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Off-Road Gas	5.0	4.6	3.9	3.9	3.9	3.9	4.7	4.3	5.8	5.4
	Off-Road Diesel	11.3	10.0	10.9	10.9	12.0	12.7	13.2	14.1	14.8	15.7
	Pipelines	6.9	7.6	10.4	10.4	10.8	12.0	12.5	12.5	12.5	12.6

Off-road fuel combustion emissions[19] in the transport sector increased between 1990 and 1999. Emissions from off-road gasoline vehicles (snowmobiles, all-terrain vehicles, etc.) rose 8%, from 5.0 Mt to 5.4 Mt, whereas emissions from off-road diesel vehicles (excavating, construction, etc.) increased by 39.4%, from 11.3 Mt to 15.7 Mt.

The pipeline emissions included in the transport sector are combustion emissions from natural gas or oil pipeline transport. Due to increasing activity in the energy sector, these emissions rose 82.2%, from 6.9 Mt in 1990 to 12.6 Mt in 1999, contributing to overall emissions growth in the transport sector.

4. Other Sectors (1999 GHG emissions, 74.6 Mt)

The other sectors category comprises fuel combustion emissions from the residential and commercial subsectors, as well as stationary fuel combustion emissions from both the agriculture and forestry sectors.[20] Overall, this category exhibited increases in GHG emissions of 3.3%, while individual subsectors within it demonstrated a variety of changes. These changes, which are reflected in Table 3.2, are discussed below.

i) Residential and Commercial

Emissions in these subsectors arise primarily from the combustion of fuel to heat residential and commercial buildings. Fuel combustion in the residential and commercial[21] subsectors accounted for 6.2% (43.0 Mt) and 4.1% (28.9 Mt), respectively, of all GHG emissions in 1999.

As shown in Figure 3.6, residential emissions declined by 2.2% between 1990 and 1999, while commercial emissions increased 12.0% over the same period. The combined effect for the two subsectors was an increase of 2.1 Mt, or 3.0%. Analysis by both Natural Resources Canada and Environment Canada has shown continuing improvement in the energy efficiency and GHG intensity of Canadian buildings. In fact, the per

19 Off-road emissions include those from the combustion of diesel and gasoline fuel in a variety of widely divergent activities. Examples include the use of heavy mobile equipment in the construction, mining, and logging sectors, recreational vehicles such as snowmobiles, and lawn and garden devices, including lawnmowers and trimmers.

20 The UNFCCC other sectors category comprises the following CGHGI sectors: residential, commercial and institutional, and other (listed under energy, fuel combustion in Tables 3.1 and 3.2 of this chapter).

21 Commercial sector emissions are based on fuel use as reported in the Quarterly Report on Energy Supply-Demand in Canada (Statistics Canada, 1999b) for ***commercial and other institutional*** and ***public administration*** categories. The former is a catch-all category that includes fuel used by service industries related to mining, wholesale and retail trade, financial and business services, education, health and social services, and other industries that are not explicitly included elsewhere.

Table 3.10 GHG Emissions from Industrial Processes by Subcategory, 1999

Main category	Subcategory	Mt CO_2 eq.
Mineral Products	Cement production Lime production Limestone use Soda ash use	8.7
Chemical Industry	Ammonia production Nitric acid production Adipic acid production	6.6
Metal Production	Iron and steel production Aluminum and magnesium production	20
Consumption of Halocarbons and SF_6		0.9
Other		14

capita degree-day emission rate of the residential and commercial categories dropped by about 7% between 1990 and 1997.

GHG emissions, particularly in the residential subsector, track heating degree-days[22] (HDD) closely (as shown in Figure 3.6). This close tracking indicates the important influence of weather on emissions on a year-to-year basis.

Activity in both the residential and commercial subsectors has increased significantly and consistently in the same period. This upward trend is counteracted by the following two influences: fuel substitution away from petroleum products and improvements in end-use efficiency. Combined, these influences have reduced energy consumption, and thus emissions, within the residential subsector.

ii) Agriculture and Forestry

Stationary fuel combustion–related emissions from the agriculture and forestry sectors amounted to 2.7 Mt in 1999, an increase of 11% since 1990. In Tables 3.1 and 3.2, these emissions are allocated to the CGHGI category Other, located within the fuel Combustion section of the energy sector.

Fugitive Emissions from Fuels

As stated above in this chapter, fugitive emissions from fossil fuels are the intentional or unintentional releases of GHGs from the production, processing, transmission, storage, and delivery of fossil fuels. Released gases that are combusted before disposal (e.g., flaring of natural gases at oil and gas production facilities) are considered fugitive emissions. Fugitive emissions have two sources: coal mining and handling, and activities related to the oil and natural gas industry. They constituted 7.6% of Canada's total GHG emissions for 1999 and contributed 16.2% to the growth in emissions between 1990 and 1999.

Table 3.6 summarizes the changes in fugitive emissions by the UNFCCC subcategories i) solid fuels and ii) oil and natural gas. In total, fugitive emissions grew by about 39% between 1990 and 1999, from 38 Mt to nearly 53 Mt, with emissions from the oil and natural gas category contributing nearly 98% of the total fugitive emissions in 1999. Although fugitive releases from the solid fuels sector (e.g., coal mining) decreased by about 830 kt (nearly 44%) between 1990 and 1999, emissions from oil and natural gas increased almost 44% over the same period.

This rise in emissions is largely due to the increased production of natural gas and heavy oil since 1990 and the increasing export of oil and natural gas to the United States.

Industrial Processes Sector (1999 GHG emissions, 50 Mt)

This category comprises emissions from industrial processes where GHGs are a direct by-

22 Heating degree-days are calculated by determining the average, cross-Canada number of days below 18°C and multiplying this value by the corresponding number of degrees below this temperature.

Figure 3.5 Trends in Vehicle Populations, 1990–1999

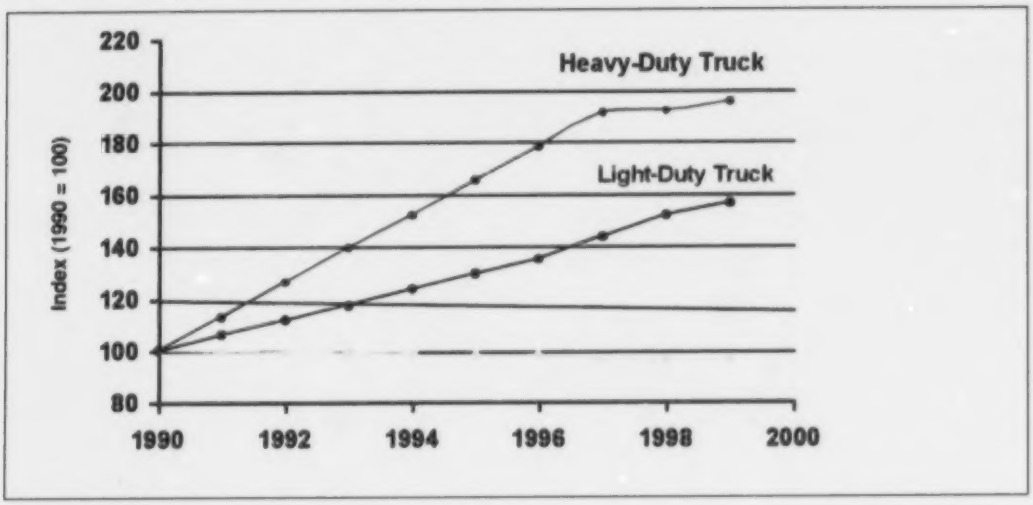


Figure 3.6 GHG Emissions from the Residential and Commercial Sectors Relative to Heating Degree-Days, 1990–1999

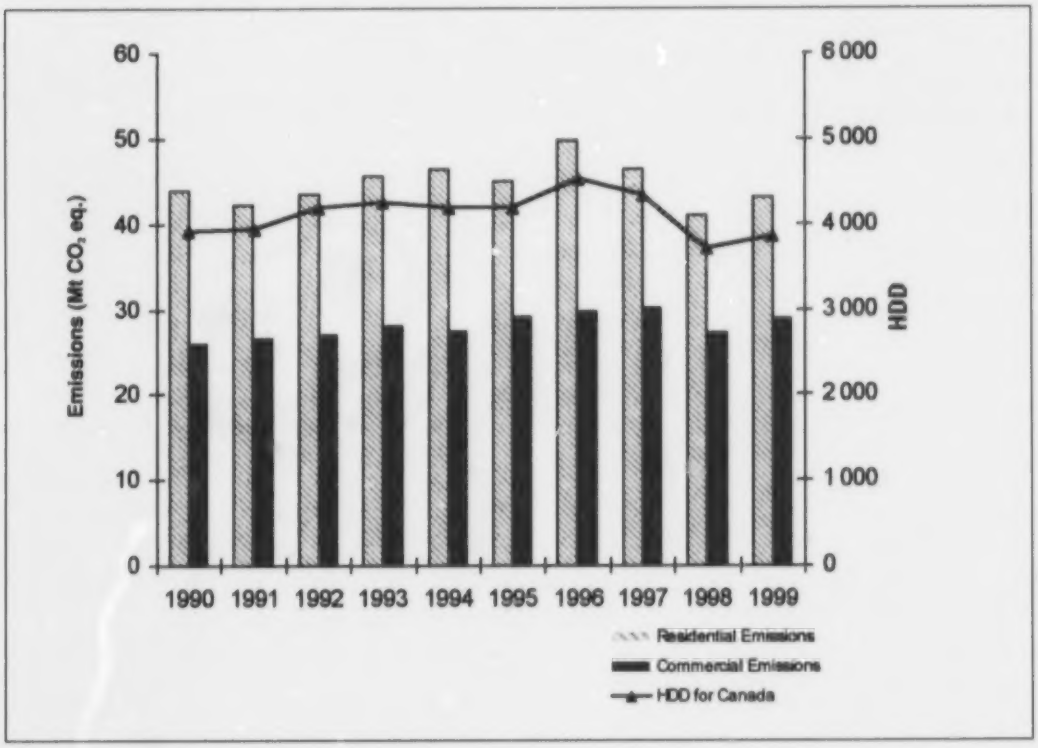
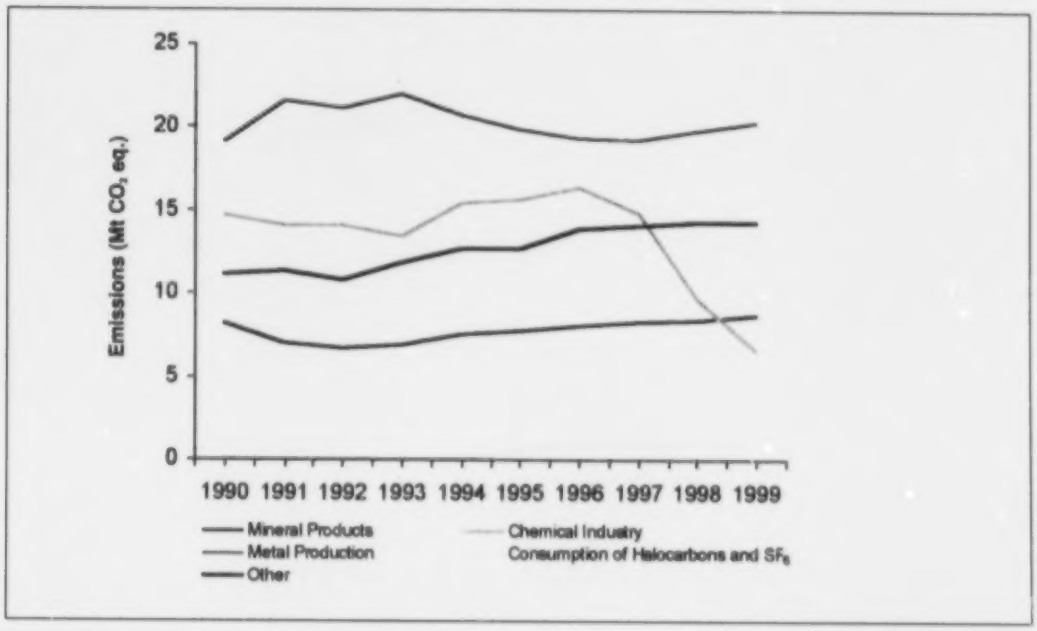


Figure 3.7 GHG Emissions from Industrial Processes by Sector, 1990–1999



product of those processes. In 1999, industrial process emissions accounted for approximately 7.3% of all GHG emissions, for a total of nearly 51 Mt, and came from diverse industrial processes defined as follows: mineral products, chemical industry, metal production,[23] consumption of halocarbons and sulphur hexafluoride,[24] and other. Figure 3.7 illustrates the changes in each of these sectors over the period 1990–1999, and Table 3.10 provides a percentage breakdown of the emissions, by subcategory, for 1999.

Although emissions from all sources within this sector either remained stable or increased between 1990 and 1999, overall sectoral emissions decreased by 2.2 Mt. The largest single source of emissions in 1999 was the metal production category with 20 Mt, as shown in Table 3.10. The *other* category accounts for the largest increase in emissions (about 28%) since 1990. These emissions are primarily from non-energy uses of fossil fuels, including the use of natural gas to produce hydrogen in the oil upgrading and refining industries, the use of natural gas liquids as feedstock in the chemicals industry, and the use of lubricants.

Despite a rising trend at the beginning of the decade, emissions declined significantly through 1997–1999: total emissions in 1999 were 4.2% below 1990 levels. This is due primarily to emissions reductions resulting from the addition of emission abatement technology in an adipic acid production process at Canada's sole production facility based in Ontario. This technology contributed to reductions of 55% in the chemical industry subsector over the period 1990–1999.

Solvent and Other Product Use Sector (1999 GHG emissions, 0.5 Mt)

While accounting for only 0.1% (0.5 Mt) of Canada's total GHG emissions in 1999, emissions in the solvent and other product use sector increased by 10.1% over 1990 levels. The

23 The UNFCCC metal production sector includes the following two sectors denoted in the CGHGI's industrial processes category: ferrous metal production and aluminum and magnesium production (see Tables 3.1 and 3.2).

24 The CGHGI allocates the consumption of halocarbons and sulphur hexafluoride to the solvent and other product use category (refer to Table 3.1).

majority of emissions in this category are related to the use of nitrous oxide as an anaesthetic in various dental and veterinary applications and as a propellant in aerosol products.[25]

Agriculture Sector (1999 GHG emissions, 61 Mt)

Canada's agriculture sector is composed of approximately 250 000 farms, 98% of which are family-owned. Agricultural emissions accounted for 8.7% (or 61 Mt) of the 1999 emissions for Canada, an increase of 3.1% since 1990. Most of these emissions are from non-energy sources, with nitrous oxide accounting for approximately 62% of sectoral emissions, methane for nearly 38%, and minor, almost negligible, emissions from carbon dioxide. Emissions from all anthropogenic activities within the agriculture sector, excluding fuel combustion, are covered in this section.

The processes that produce GHG emissions in the agriculture sector are enteric fermentation[26] of domestic animals, manure management practices, and cropping practices that result in a release from soils. Relative changes in emissions in each of these categories are shown in Figure 3.8. Emissions in this sector were analyzed based upon the following two main categories:

- Livestock-related emissions due to enteric fermentation from domestic animals (i.e., digestive processes that release significant quantities of methane) and manure management (which releases methane and nitrous oxide). These emissions accounted for nearly 4% of Canada's GHG emissions in 1999.
- Soil management and cropping practices contributing emissions of carbon dioxide (due to decomposition of organic carbon from the soil) and nitrous oxide (due to fertilizer application and cropping practices). Soil-related sources accounted for about 5% of total GHG emissions in 1999.

In the 1990–1999 period, livestock emissions increased 11.4%, while emissions from soils declined by 3.1%. Most of the increase (about 95%) in livestock-related emissions is attributable to increased cattle production. Uncertainty in the estimates of emissions from agricultural soils is high, but it is believed that carbon dioxide emissions have been steadily declining, mainly due to increasing use of conservation tillage.

The 1999 GHG inventory for the agriculture sector reflects a few major changes from the past. These changes are the result of consultations with Canadian and U.S. agricultural soil and crop experts, federal and provincial soil and crop specialists, and recent changes in the U.S. inventory specifically related to the annual nitrogen excretion rates for various domestic animals. As a result of these changes, there is an emissions reduction of 9 Mt for the base year of 1990 (68 Mt vs. 59 Mt) (Environment Canada, 2001).

Land Use Change and Forestry Sector (1999 GHG emissions, 2.4 Mt)

Estimates of net carbon dioxide and other GHG fluxes in Canada's land use change and forestry (LUCF) sector have been reported on since 1996. The net carbon dioxide flux amounts to a sink, declining from 61 Mt in 1990 to 20 Mt in 1999. As per current UNFCCC guidelines (IPCC, 1997), carbon dioxide fluxes in the LUCF sector are excluded from inventory totals. The LUCF net carbon dioxide removals, if included, would decrease the total Canadian GHG emissions by 10% in 1990 down to 3% in 1999 (Figure 3.9).

Non–carbon dioxide fluxes in the LUCF sector, which are composed of methane and nitrous oxide emissions, are included in the national inventory totals. These emissions represent about 0.3% of total GHG emissions for Canada.

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25 The CGHGI also includes HFC emissions from refrigeration and air conditioners within the solvent and other product use sector, whereas the UNFCCC Guidelines allocate these emissions to the industrial processes sector.

26 Enteric fermentation is a digestive process whereby carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream. This process results in methanogenesis in the rumen, and the methane is emitted by eructation and exhalation. Some methane is released later in the digestive process by flatulation. Animal eructation and manure methane emissions are directly proportional to animal populations. Emission estimates have been made based on animal populations and emission rates that reflect conditions in Canada.

Figure 3.8 GHG Emissions from Agricultural Sources, 1990–1999

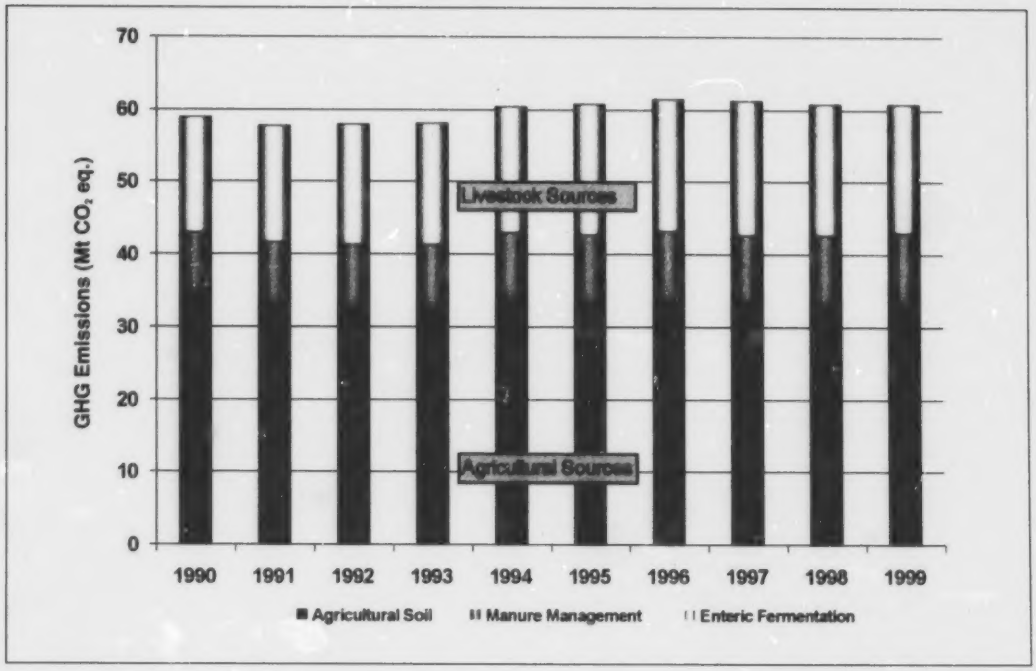
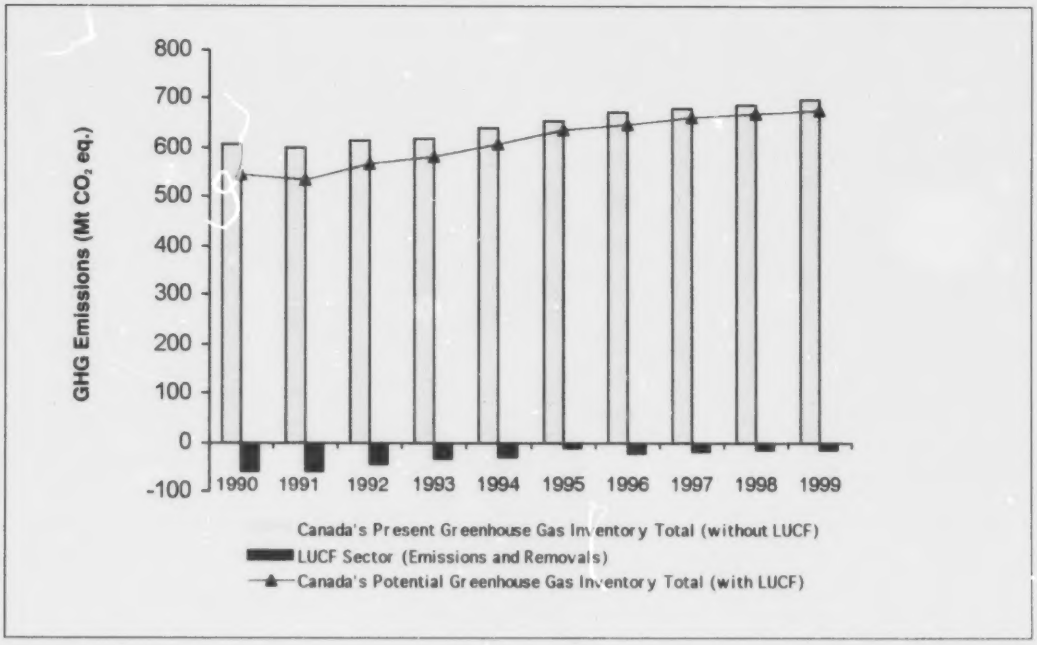


Figure 3.9 Contribution of LUCF Sector to Canada's GHG Emissions Totals, 1990–1999



Overall, the LUCF sector, calculated as the sum of the net carbon dioxide flux (a removal) and non–carbon dioxide emissions, remained a net sink for the period 1990–1999. The general trend indicates a decline in the net removal from 59 Mt in 1990 to less than 20 Mt in 1999, an approximate 65% decrease over the decade.

The LUCF sector has distinctive characteristics. GHGs are emitted to the atmosphere through the oxidation of living and dead organic matter and absorbed by vegetation through photosynthesis. Both emissions and removals are large fluxes resulting from minute processes dispersed over a vast land area. Land use and land use practices directly alter the size and rate of these natural exchanges of GHGs between the terrestrial landscape and the atmosphere, both in the present and over long time periods. Understanding and measuring the flux components due to human intervention represent unique scientific and accounting challenges. The methods involve more steps and require more data, factors, and assumptions to derive estimates than in most other inventory sectors. In many cases, data are simply not available, and calculations rely on a wide variety of assumptions and parameters.

Estimates of GHG fluxes in the LUCF sector of the CGHGI are drawn from an accounting model built from a recent report that produces estimates back to 1990 (Environment Canada, 2001).

While there is reasonable confidence in the overall trend direction, the flux estimates themselves are characterized by a high degree of uncertainty and should be treated as first approximations only. To reflect this uncertainty, figures in the CGHGI have been rounded. The magnitude of the net forest sink is likely to be significantly underestimated due to the omission in the model of several carbon stocks, notably the forest product sector and forest soils and litter. Work is ongoing to incorporate these carbon pools into the accounting.

In the LUCF sector, GHG emissions to the atmosphere from sources and removals by sinks are reported and added for five categories:

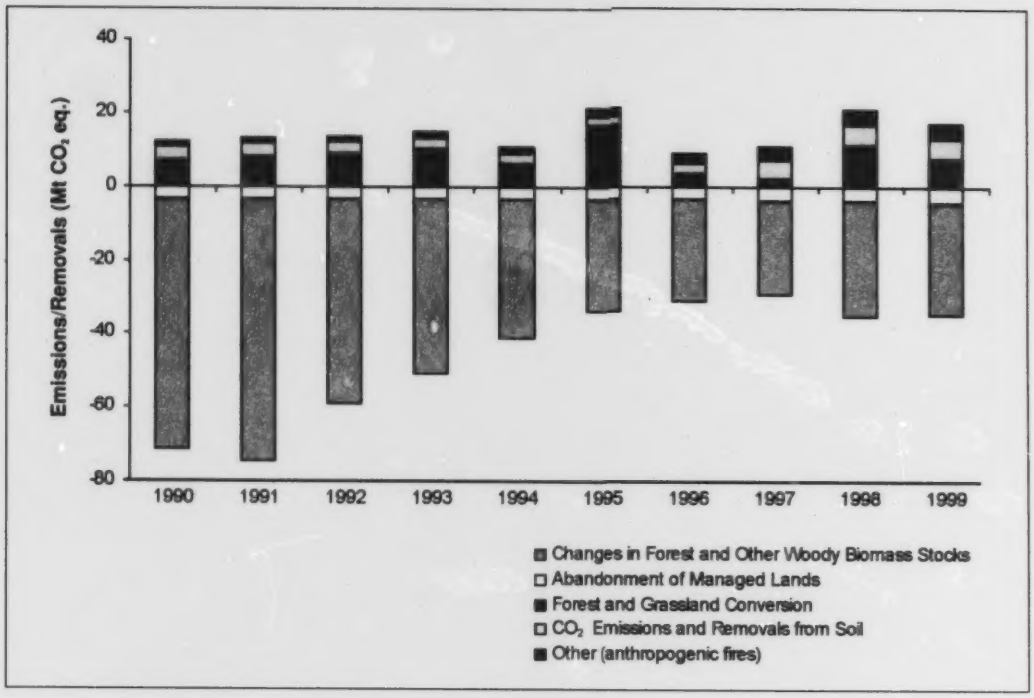
- changes in forest and other woody biomass stocks;
- forest and grassland conversion;
- abandonment of managed lands;
- carbon dioxide emissions and removals from soil; and
- other.

Of these five categories, the largest and most influential in terms of total emissions/removals is the first: changes in forest and other woody biomass stocks (Figure 3.10). It generally represents 90% of all carbon dioxide removals in the LUCF sector and displays a trend similar to the overall one, with sinks declining by half between 1990 and 1999. The two most important components of this category are the forest tree growth and harvesting activities. While the carbon dioxide uptake associated with tree growth has remained fairly constant during the decade, carbon dioxide release due to harvesting activities has increased significantly, as indicated by a 16% rise in the domestic production of industrial roundwood. The general decline in sinks over the period hence reflects the sensitivity of the accounting model to changes in industrial forestry activities.

Planned improvements of the LUCF inventory include a more explicit account of fire emissions in and outside the wood production forest and the inclusion of all carbon pools to the forest carbon accounting. A new National Forest Inventory, currently under development, will provide better data for monitoring carbon stock changes in Canadian forests.

The only other category displaying a net carbon dioxide removal is abandonment of managed lands. This removal reflects carbon sequestration in above-ground biomass on agricultural land that is reverting to its natural state (grassland or forest) over a 100-year time horizon. Carbon dioxide removals in this sector increased by approximately 23% for the period 1990–1999, from 3.2 to 4.0 Mt. This minor contribution to sinks (10%) should also be weighted by the large uncertainty associated with poor information on the fate of abandoned farmland in Canada.

Figure 3.10 LUCF Sector Emissions and Removals by Subcategories, 1990–1999



The three other categories of the LUCF sector are carbon dioxide emitters to the atmosphere. The largest contributor is the *other* category, which includes carbon dioxide emissions from anthropogenic fires outside the wood production forest (emissions associated with anthropogenic fires in the wood production forest are included in the changes in forest carbon stocks) and non–carbon dioxide emissions from all anthropogenic forest fires regardless of location. The quantity of GHGs released by fires is based on the area burned annually and displays the large variability typical of natural disturbances. The non–carbon dioxide GHGs emissions of this category are reported in the Canadian inventory totals.

The forest and grassland conversion category accounts for the carbon released from above-ground biomass on forest lands and grasslands converted to other land uses. Emissions tripled over the period, from 1.4 Mt in 1990 to 4.2 Mt in 1999. Post-1996 activity data are also the result of projections, whose accuracy will not be confirmed until the release of the next agricultural census in 2001. A further source of uncertainty arises from the method used to obtain estimates of land conversion, which are derived from the net annual changes in the area of agricultural and urban lands in each Canadian province. These net changes may in turn result from very different combinations of land conversion and abandonment. Estimates of GHG emissions derived from a net change in the area of agricultural land almost certainly differ from those based on the difference between emissions from land conversion and removals by abandoned land. Consequently, the estimated emissions and removals in this category are indicative only. A better monitoring of land use changes in Canada is a priority for improving this component of the LUCF inventory.

In the CGHGI, carbon dioxide exchanges between soils and the atmosphere in the LUCF sector relate to land use changes only. They are calculated as the net effect of emissions due to land conversion from forest and grassland to other land uses, on the one hand, and removals due to carbon sequestration in soils of abandoned agricultural lands, on the other hand. Emissions and removals from agricultural soils and liming

are included in the agriculture sector of the inventory. Emissions from soils consistently exceeded removals by soils for the period, with net annual emissions estimated between 2.4 and 5.3 Mt. Emissions tended to decrease until 1995 and increase steeply thereafter, with a sudden doubling of emissions between 1996 and 1997. Based on data from previous years, the model projected a substantial increase in the area of grassland conversion to agricultural lands in 1997.

Overall, the trends observed in the LUCF category largely reflect changes in industrial forestry activity during the 1990s. However, the methodology itself does not include all carbon sources and sinks: forest soils and wood products, two significant carbon pools, are not accounted for in the carbon stock changes in the forest. The Canadian forest product sector retains an estimated 45% of the carbon harvested annually (Apps *et al.*, 1999); including this component in the calculations would significantly reduce the apparent impact of industrial activity on sinks.

Waste Sector (1999 GHG emissions, 24 Mt)

From 1990 to 1999, carbon dioxide equivalent emissions from waste increased 17.3%, surpassing the population growth of 10%. By 1999, these emissions represented 3.4% of Canadian GHG emissions, a slight increase from 3.3% in 1990. These emissions consist almost entirely of methane produced by the decomposition of biomass in municipal solid waste; in 1999, emissions from solid waste disposal on land totalled nearly 22.0 Mt, while municipal wastewater and incinerated material derived from fossil fuel products contributed 1.3 Mt and 0.3 Mt, respectively. Table 3.2 summarizes the annual changes in each of the three waste sector subcategories between 1990 and 1999.

Methane emissions from landfills increased by nearly 18% between 1990 and 1999 despite an increase in landfill gas capture and combustion of almost 33% over the same period. In 1999, there were 42 landfill gas collection systems capturing 280 kt of methane per year, for a reduction of 6.1 Mt per year. There were eight landfill gas-to-energy plants generating 85.3 MW of electricity and eight more landfill gas systems feeding nearby industries.

GHG emissions from landfills are tabulated for two types of waste, municipal solid waste and wood waste landfills, both of which produce methane anaerobically.[27] The methane production rate at landfills is a function of several factors, including the mass and composition of biomass being landfilled, the landfill temperature, and the moisture entering the site from rainfall.

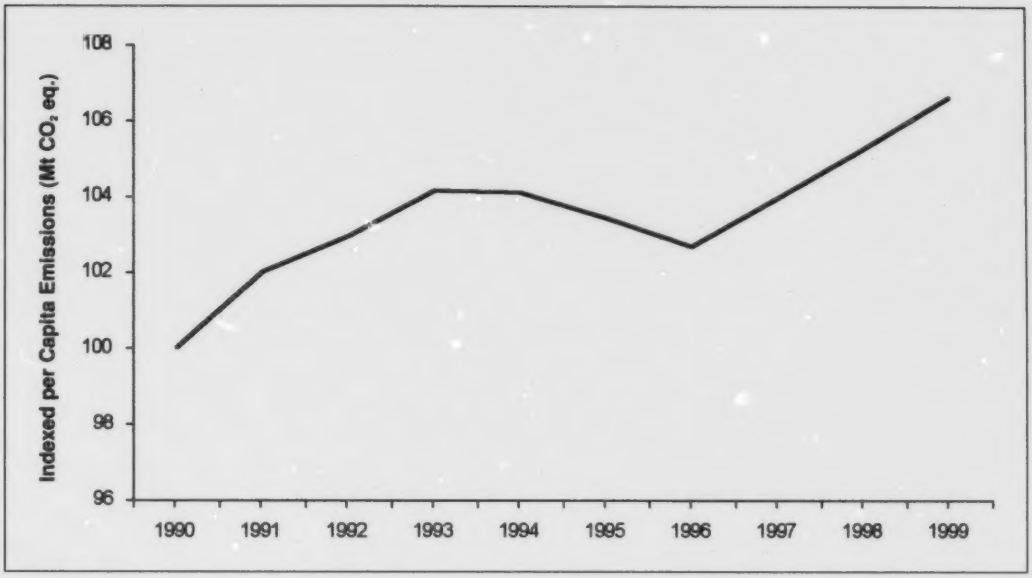
Per capita emissions from this sector increased 6.6% from 1990 to 1999, due primarily to the increasing emissions from landfills (Figure 3.11). Methane capture programs at landfills have made significant contributions to reductions in emissions in this period. Trend growth exceeds population increases, since material landfilled in past decades is still contributing to methane production. The decline in per capita growth observed in the mid-1990s, shown in Figure 3.11, is directly attributable to methane capture programs at landfills.

Greenhouse Gases and Global Warming Potentials

Naturally occurring GHGs include water vapour, carbon dioxide, methane, nitrous oxide, and ozone. CFCs and their substitutes, HFCs and hydrochlorofluorocarbons (HCFCs), and other compounds, such as PFCs and sulphur hexafluoride, are also GHGs. The UNFCCC excludes those gases covered by the Montreal Protocol (CFCs and HCFCs). However, other photochemically important gases, such as carbon monoxide, oxides of nitrogen, and non-methane volatile organic compounds, while not direct GHGs, do contribute indirectly to the greenhouse effect by creating tropospheric ozone and, as such, are included under the UNFCCC. Direct effects occur when the gas itself is a GHG, while indirect radiative forcing occurs when chemical transformation of the original gas produces a

27 When waste consists of biomass, the carbon dioxide produced from burning or aerobic decomposition of the waste is not accounted for in the waste sector, as it is deemed a sustainable cycle (carbon in carbon dioxide will be sequestered when the biomass regenerates). In theory, emissions of carbon dioxide are accounted for as part of the wood products pool within the LUCF sector; however, waste that decomposes anaerobically produces methane, which is not used photosynthetically and therefore does not sequester carbon in biomass. The production and release of unburned methane from waste are therefore accounted for in GHG inventories.

Figure 3.11 Per Capita GHG Emissions Trend for Waste, 1990–1999



GHG or GHGs or when a gas influences the atmospheric lifetimes of other gases.

The concept of global warming potential (GWP) has been developed to allow scientists and policy makers to compare the ability of each GHG to trap heat in the atmosphere relative to another gas. By definition, a GWP is the time-integrated change in radiative forcing due to the instantaneous release of 1 kg of a trace gas expressed relative to the radiative forcing from the release of 1 kg of carbon dioxide. In other words, a GWP is a relative measure of the warming effect that the emission of a radiative gas might have on the surface troposphere. The GWP of a GHG takes into account both the instantaneous radiative forcing due to an incremental concentration increase and the lifetime of the gas. While any time period can be chosen for comparison, the 100-year GWPs are used, as per UNFCCC guidelines (Decision 3/CP.5).

Uncertainties

A particular concern with emissions inventories is their accuracy. While the uncertainties result from many causes, most are due to the following:

- differences in the interpretation of source and sink category definitions, assumptions, units, etc.;
- inadequate and incorrect socio-economic activity data used to develop the emissions estimates;
- inappropriate application of emissions factors to situations and conditions for which they do not apply; and
- actual empirical uncertainty of measured emissions data and the basic processes leading to emissions.

In 1994, Environment Canada completed a study of the underlying uncertainties associated with Canada's GHG emissions estimates. The result was a quantitative assessment of the reliability inherent in the 1990 inventory, as then compiled. Overall uncertainties were developed based on a stochastic model and were estimated to be about 4% for carbon dioxide, 30% for methane, and 40% for nitrous oxide. It should be noted that individual sector uncertainties can be even greater. In addition, as far as inventories go, the uncertainties associated with carbon dioxide,

which dominates the GHG inventory, are very low.

The approach taken to developing uncertainties made use of Monte Carlo stochastic computer simulations. Individual uncertainty range estimates by industry experts were skewed in some cases (i.e., not *normally* distributed), necessitating the use of Monte Carlo stochastic computer simulation to develop group and then overall uncertainty estimates for each GHG. Up to 100 000 iterations were used in these simulations to provide the final estimates of uncertainty at confidence levels ranging from 85% to 95%. While the uncertainties were calculated for the 1990 inventory, many data sources and emission rates have remained the same, as have the methods used to estimate emissions. Thus, it is reasonable to assume that the uncertainty in the carbon dioxide and methane emissions are still of the same order. Further studies of inventory uncertainty are planned for the near future.

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ANNEX 1: GHG INVENTORY METHODOLOGY

In general, an emissions inventory can be defined as a *comprehensive account of air pollutant emissions and associated data from sources within the inventory area over a specified time frame*. Ideally, an inventory would be compiled from the measured emissions or removals from every source and sink in the country. While it may be the ideal, a comprehensive bottom-up inventory is neither practicable nor possible. Due to the sheer number of sources and sinks, it would be virtually impossible for any country to capture them all. The best a country can do is strive to make its inventory as complete as possible using the resources at its command.

In general, the CGHGI is divided between *point sources* and *area sources*. Point sources refer to individual sources or facilities. Area sources are sources that are too dispersed and/or too numerous for individual source measurement.

Point source emissions may be measured or estimated from information assembled from individual plant or facility throughput and emission factors. However, GHG emissions and removals have not normally been measured for regulatory or compliance purposes; as such, emissions or removals, whether for point or for area sources, have usually been calculated or estimated.

To date, emissions have been calculated using general or average emission factors, mass-balance approaches, or stoichiometric relationships under averaged conditions. These techniques result in estimates that are compiled in what is generally referred to as a *sectoral* approach.

For large area sources, carbon budgets, to account for source/sink balances, and modelling estimates, using the best available averaged parameters, are used for some of the large, meteorologically dependent open sources (e.g., forest biomass balances, landfills, and agricultural soils). Other large-scale regional or national emission estimates under averaged conditions have been compiled to date for collective sources such as transportation.

GHG emissions may be derived for a given process or combination of operations by one or more of the following methods:

- *Direct measurement*: With a few exceptions, GHG emissions or removals measurements apply to point sources. At present, a very limited number of sources have measured and reported GHG emissions.

- *Mass balance*: This approach determines atmospheric emissions from the difference between the amounts of the component (carbon, for example) contained in feed materials or fuels and those contained in the products, process wastes, or non-emitted residuals. *Mass balances* are most appropriately applied to fuel carbon contributions and mineral-processing activities, where sufficient data are available to derive average carbon contents of process streams. Generally, carbon dioxide emissions resulting from fuel combustion are readily estimated by the *carbon balance* method.

- *Technology-specific emission factor calculations*: Company-specific emission factors (EFs) can be used to estimate the rate at which a pollutant is released into the atmosphere (or captured) as a result of some process activity or unit throughput. Although emissions or removals may not be measured, individual facilities may have measured rate data for various parameters for their plant. This can be combined with other plant-specific information such as throughput, activity data, and the number of such sources to derive plant-specific emissions or removals for a point source or "bottom-up" inventory.

- *Average or general emission factor calculations*: Where plant-specific data are not available, average or general EFs can be used for a given source or sector. These average EFs can be combined with company-specific, sector-specific, process-specific, or general activity and population data to calculate emissions for an inventory. Average or general EFs for most of the sectors in the inventory have been developed by Environment Canada, in consultation with other government departments, industry associations, and other agencies and organizations. These values

reflect the most accurate methodologies based on currently available data and include information currently being developed by the IPCC for the UNFCCC. In general, carbon dioxide EFs are well developed for many sources, methane factors are less well defined, and nitrous oxide, PFC, HFC, and sulphur hexafluoride factors are often limited and less certain.

Some methods have undergone revision since the release of the previously published 1998 inventory[28] (Environment Canada, 2000). The significant areas of revision are as follows:

- *Energy*: Modifications in this sector include revised carbon dioxide EFs, revised methane and nitrous oxide EFs from the combustion of fossil fuel, and revised residential fuel wood use data.

- *Industrial processes*: Sectoral upgrades here include revision of the carbon content of metallurgical coke, as well as new PFC consumption–related emissions data.

- *Agriculture*: Method alterations in the agriculture sector comprise revised leaching and runoff nitrogen loss rates, revision of the area of histosols under cultivation, and the elimination of crop residues from alfalfa.

The changes in emissions data are the result of improved or new data and better scientific understanding of emissions. The revisions have been implemented in accordance with the recalculation procedures outlined in the IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories (IPCC, 2000) and have no impact on the overall emissions trend.

28 A more detailed explanation of the method revisions can be found in Canada's Greenhouse Gas Inventory 1990–1999 (Environment Canada, 2001).

Annex 2 **Commc.1 Reporting Format Tables**

Table 3.A.1 **Summary Report for CO_2 Equivalent Emissions – (Sheet 1 of 2)***

Canada
1998
Submission 2000

Greenhouse Gas Source and Sink Categories	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**507 597.89**	**89 479.89**	**64 895.61**	**864.07**	**6 023.17**	**1 536.21**	**670 396.84**
1. Energy	**490 213.33**	**43 772.36**	**11 143.27**				**545 128.96**
A. Fuel Combustion (Sectoral Approach)	476 426.48	5 148.45	11 143.27				492 718.20
1. Energy Industries	181 201.43	43.60	996.65				182 241.68
2. Manufacturing Industries and Construction	53 128.59	36.20	501.89				53 666.68
3. Transport	174 251.81	527.45	8 703.87				183 483.13
4. Other Sectors	67 844.65	4 541.20	940.86				73 326.71
5. Other	0.00	0.00	0.00				0.00
B. Fugitive Emissions from Fuels	13 786.85	38 623.91	0.00				52 410.76
1. Solid Fuels	0.00	1 364.06	0.00				1 364.06
2. Oil and Natural Gas	13 786.85	37 259.86	0.00				51 046.71
2. Industrial Processes	**38 065.75**	**0.00**	**5 837.30**	**864.07**	**6 023.17**	**1 536.21**	**52 326.50**
A. Mineral Products	8 360.74	0.00	0.00				8 360.74
B. Chemical Industry	3 898.29	0.00	5 837.30	0.00	0.00	0.00	9 735.59
C. Metal Production	12 133.11	0.00	0.00		6 023.17	1 536.21	19 692.50
D. Other Production [2]	0.00						
E. Production of Halocarbons and SF_6				0.00	0.00	0.00	0.00
F. Consumption of Halocarbons and SF_6				864.07	0.00	0.00	864.07
G. Other	13 673.61	0.00	0.00	0.00	0.00	0.00	13 673.61
3. Solvent and Other Product Use	**0.00**		**456.97**				**456.97**
4. Agriculture	**875.00**	**23 043.93**	**45 582.67**				**69 501.60**
A. Enteric Fermentation		17 964.03					17 964.03
B. Manure Management		5 079.90	5 040.28				10 120.18
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils [2]	875.00	0.00	40 542.39				41 417.39
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry [1]	**-21 833.00**	**875.70**	**868.00**				**-20 089.30**
6. Waste	**276.82**	**21 787.89**	**1 007.40**				**23 072.11**
A. Solid Waste Disposal on Land	0.00	21 387.06					21 387.06
B. Wastewater Handling		393.91	949.16				1 343.07
C. Waste Incineration	276.82	6.92	58.24				341.98
D. Other	0.00	0.00	0.00				0.00
7. Other (*please specify*)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
							0.00
Memo Items:							
International Bunkers	**6 654.90**	**3.01**	**258.10**				**6 916.02**
Aviation	2 878.90	1.86	87.49				2 968.25
Marine	3 776.00	1.15	170.61				3 947.77
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**62 820.69**						**62 820.69**

(1) For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

(2) See footnote 4 to Summary 1.A of this common reporting format.

Table 3.A.1 Summary Report for CO_2 Equivalent Emissions – (Sheet 2 of 2)*

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	Net CO_2 Emissions/ Removals	CH_4	N_2O	Total Emissions
	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	256 424.00	-289 454.00	-33 030.00			-33 030.00
B. Forest and Grassland Conversion	3 924.00		3 924.00	0.00	0.00	3 924.00
C. Abandonment of Managed Lands	0.00	-4 008.00	-4 008.00			-4 008.00
D. CO_2 Emissions and Removals from Soil	9 726.00	-4 465.00	5 261.00			5 261.00
E. Other	6 020.00	0.00	6 020.00	875.70	868.00	7 763.70
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	**276 094.00**	**-297 927.00**	**-21 833.00**	**875.70**	**868.00**	**-20 089.30**
			Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [(a) & (b)]			**690 486.14**
			Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [(a)]			**670 396.84**

(a) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.

(b) National Net CO_2 Equivalent Emissions without CO_2 from LUCF is found on Table 8(a) Recalculation and on Table 10: Emission Trends (Summary).

* These tables were extracted from Canada's Greenhouse Gas Inventory 1990-1998: Final Submission to the UNFCCC Secretariat, Volume 2 of 2, Environment Canada, Ottawa, August 2000. The updated 1999 GHG inventory data is published in Canada's Greenhouse Gas Inventory 1990-1999: Common Reporting Format Tables, Environment Canada, Ottawa, April 2001. Electronic (PDF) and hard copies can be requested at the following e-mail address: ghg@ec.gc.ca.

Table 3.A.2 Emissions Trends (CO_2) – (Sheet 1 of 5)*

Greenhouse Gas Source and Sink Categories	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Energy	0.00	425 522.60	415 952.43	430 379.55	428 225.48	441 781.36	453 938.96	466 430.10	478 451.52	490 213.31
A. Fuel Combustion (Sectoral Approach)	0.00	415 689.94	405 838.12	419 730.09	416 893.42	429 922.90	440 965.07	452 945.30	464 819.25	476 426.45
1. Energy Industries		144 599.39	143 299.33	151 415.25	145 493.99	148 410.88	154 327.58	154 517.31	162 940.86	181 201.44
2. Manufacturing Industries and Construction		56 067.14	53 333.11	52 790.00	49 961.07	53 045.03	53 482.91	55 303.27	55 225.84	53 128.58
3. Transport		145 833.36	140 611.09	144 669.11	147 814.16	155 224.21	159 440.35	163 927.85	170 334.69	174 251.80
4. Other Sectors		69 190.05	68 594.59	70 855.72	73 624.20	73 242.79	73 714.23	79 196.87	76 317.86	67 844.63
5. Other										
B. Fugitive Emissions from Fuels	0.00	9 832.66	10 114.31	10 649.46	11 332.06	11 858.46	12 973.89	13 484.80	13 632.27	13 786.85
1. Solid Fuels		NI	NI	NI	NI	NI	NI	NI	NI	NI
2. Oil and Natural Gas		9 832.66	10 114.31	10 649.46	11 332.06	11 858.46	12 973.89	13 484.80	13 632.27	13 786.85
2. Industrial Processes	0.00	32 724.27	33 508.01	33 121.36	34 886.29	35 785.68	36 464.45	38 065.81	38 398.74	38 065.75
A. Mineral Products		8 160.68	6 980.56	6 635.75	6 875.20	7 507.44	7 691.42	8 034.29	8 167.63	8 360.74
B. Chemical Industry		3 126.54	3 218.71	3 317.38	3 561.96	3 700.33	4 051.22	4 128.22	4 141.79	3 898.29
C. Metal Production		10 221.52	11 918.25	12 296.95	12 528.29	11 767.27	11 984.32	12 014.51	11 894.66	12 133.11
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other		11 215.53	11 390.49	10 871.28	11 920.84	12 810.64	12 737.49	13 888.79	14 194.66	13 673.61
3. Solvent and Other Product Use		NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agriculture	0.00	7 255.00	6 652.00	5 777.00	4 662.00	4 224.00	3 166.00	1 784.00	1 248.50	875.00
A. Enteric Fermentation		NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Manure Management		NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Rice Cultivation		NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils [2]		7 255.00	6 652.00	5 777.00	4 662.00	4 224.00	3 166.00	1 784.00	1 248.50	875.00
E. Prescribed Burning of Savannas		NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues		NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other										
5. Land-Use Change and Forestry[3]	0.00	-39 141.04	-57 269.38	-45 351.53	-34 578.61	-29 728.80	-21 128.54	-28 885.76	-23 624.91	-21 833.00
A. Changes in Forest and Other Woody Biomass Stocks		-45 224.00	-63 839.03	-52 966.60	-43 060.69	-33 243.73	-34 192.50	-37 224.33	-34 695.57	-33 030.00
B. Forest and Grassland Conversion		1 419.00	1 393.00	1 420.00	1 699.00	2 056.00	2 381.00	2 840.00	3 694.00	3 924.00
C. Abandonment of Managed Lands		-3 245.00	-3 304.00	-3 271.00	-3 242.00	-3 216.00	-3 183.00	-3 157.00	-3 913.00	-4 008.00
D. CO_2 Emissions and Removals from Soil		3 526.00	3 776.77	3 137.28	2 841.76	2 630.29	2 391.63	2 635.92	5 270.02	5 261.00
E. Other		4 382.96	4 703.88	6 328.79	7 183.31	2 044.64	11 474.33	6 019.65	6 019.65	6 020.00
6. Waste	0.00	253.52	256.64	260.73	264.77	267.97	271.42	274.69	277.34	276.82
A. Solid Waste Disposal on Land		NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Waste-water Handling		NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Waste Incineration		253.52	256.64	260.73	264.77	267.97	271.42	274.69	277.34	276.82
D. Other										
7. Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Emissions/Removals with LUCF *	0.00	426 614.35	399 099.71	424 187.10	433 459.92	452 330.20	472 712.28	477 668.84	494 751.19	507 597.87
Total Emissions without LUCF *	0.00	465 755.39	456 369.09	469 538.64	468 038.53	482 059.00	493 840.82	506 554.60	518 376.10	529 430.87
Memo Items:										
International Bunkers	0.00	5 724.08	5 581.22	5 865.96	5 310.23	5 649.64	5 915.97	6 159.04	6 037.62	6 653.37
Aviation		2 729.27	2 482.68	2 685.15	2 472.48	2 460.75	2 603.53	3 073.52	2 991.66	2 877.64
Marine		2 994.81	3 098.54	3 180.81	2 837.75	3 188.89	3 312.44	3 085.52	3 045.96	3 775.73
Multilateral Operations										
CO_2 Emissions from Biomass		58 153.26	59 959.51	62 226.56	61 105.73	64 536.06	66 819.47	66 262.59	70 290.76	62 820.69

Table 3.A.2 Emissions Trends (CH_4) – (Sheet 2 of 5)*

Greenhouse Gas Source and Sink Categories	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998
					(Gg)					
Total Emissions	0.00	3 541.73	3 668.91	3 788.83	3 916.06	4 018.44	4 162.57	4 294.18	4 317.31	4 260.93
1. Energy	0.00	1 595.92	1 665.79	1 791.20	1 854.46	1 932.87	2 027.57	2 153.18	2 150.06	2 084.40
A. Fuel Combustion (Sectoral Approach)	0.00	258.04	261.01	280.01	281.48	277.01	274.81	283.86	284.88	245.16
1. Energy Industries		1.72	1.71	1.78	1.72	1.75	1.86	1.87	1.88	2.08
2. Manufacturing Industries and Construction		1.54	1.51	1.54	1.49	1.58	1.74	1.72	1.73	1.72
3. Transport		24.87	23.72	23.02	22.99	23.43	23.20	23.81	23.48	25.12
4. Other Sectors		229.91	234.07	253.67	255.29	250.25	248.01	256.46	257.80	216.25
5. Other										
B. Fugitive Emissions from Fuels	0.00	1 337.88	1 404.78	1 511.19	1 572.98	1 655.86	1 752.76	1 869.32	1 865.17	1 839.23
1. Solid Fuels		91.16	99.35	87.35	87.32	84.09	81.58	84.13	78.07	64.95
2. Oil and Natural Gas		1 246.72	1 305.43	1 423.84	1 485.66	1 571.77	1 671.19	1 785.19	1 787.10	1 774.28
2. Industrial Processes	0.00	NE	NE	NE	NE	NE	NE	NE	NE	NE
A. Mineral Products										
B. Chemical Industry										
C. Metal Production										
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other										
3. Solvent and Other Product Use		NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agriculture	0.00	980.44	987.53	972.08	1 016.03	1 064.59	1 099.31	1 107.70	1 110.69	1 097.32
A. Enteric Fermentation		761.62	769.02	759.54	795.47	833.69	860.89	866.50	874.84	855.42
B. Manure Management		218.82	218.51	212.54	220.56	230.90	238.42	241.20	235.84	241.89
C. Rice Cultivation		NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils		NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Prescribed Burning of Savannas		NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues		NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other										
5. Land-Use Change and Forestry	0.00	65.70	86.10	75.50	72.60	37.10	47.40	41.70	41.70	41.70
A. Changes in Forest and Other Woody Biomass Stocks		NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Forest and Grassland Conversion		NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Abandonment of Managed Lands		NA	NA	NA	NA	NA	NA	NA	NA	NA
D. CO_2 Emissions and Removals from Soil		NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Other		65.70	86.10	75.50	72.60	37.10	47.40	41.70	41.70	41.70
6. Waste	0.00	899.67	929.49	950.04	972.97	983.88	988.29	991.61	1 014.87	1 037.52
A. Solid Waste Disposal on Land		882.25	911.85	932.11	954.96	965.67	969.80	972.90	995.95	1 018.43
B. Wastewater Handling		16.98	17.19	17.45	17.70	17.90	18.14	18.37	18.59	18.76
C. Waste Incineration		0.44	0.45	0.49	0.31	0.31	0.34	0.33	0.33	0.33
D. Other										
7. Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Memo Items:										
International Bunkers	0.00	0.15	0.13	0.13	0.12	0.13	0.14	0.15	0.14	0.14
Aviation		0.08	0.07	0.08	0.07	0.07	0.08	0.09	0.09	0.09
Marine		0.07	0.06	0.05	0.05	0.05	0.06	0.06	0.05	0.05
Multilateral Operations										
CO_2 Emissions from Biomass										

Table 3.A.2 Emissions Trends (N_2O) – (Sheet 3 of 5)*

Greenhouse Gas Source and Sink Categories	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998
					(Gg)					
Total Emissions	0.00	202.56	202.01	202.11	206.93	220.47	223.05	231.45	225.89	209.33
1. Energy	0.00	27.96	28.44	30.61	32.61	35.13	36.24	36.32	36.81	35.94
A. Fuel Combustion (Sectoral Approach)	0.00	27.96	28.44	30.61	32.61	35.13	36.24	36.32	36.81	35.94
1. Energy Industries		2.58	2.63	2.74	2.60	2.72	2.82	2.85	2.99	3.22
2. Manufacturing Industries and Construction		1.43	1.45	1.46	1.38	1.44	1.62	1.55	1.57	1.62
3. Transport		20.77	21.14	22.93	25.10	27.50	28.35	28.33	28.66	28.08
4. Other Sectors		3.18	3.23	3.48	3.52	3.46	3.45	3.59	3.58	3.03
5. Other										
B. Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels		NA	NA	NA	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas		NA	NA	NA	NA	NA	NA	NA	NA	NA
2. Industrial Processes	0.00	37.08	34.73	34.60	31.80	37.85	37.12	39.56	34.43	18.83
A. Mineral Products		NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry		37.08	34.73	34.60	31.80	37.85	37.12	39.56	34.43	18.83
C. Metal Production		NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other										
3. Solvent and Other Product Use		1.35	1.37	1.39	1.41	1.42	1.44	1.46	1.47	1.47
4. Agriculture	0.00	129.69	129.96	128.25	133.82	140.54	141.57	148.10	147.14	147.04
A. Enteric Fermentation		NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Manure Management		13.69	13.91	14.16	14.57	15.45	15.96	16.20	16.50	16.26
C. Rice Cultivation		NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils		116.00	116.04	114.08	119.25	125.09	125.61	131.91	130.64	130.78
E. Prescribed Burning of Savannas		NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues		NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other										
5. Land-Use Change and Forestry	0.00	3.50	4.50	4.20	4.20	2.40	3.50	2.80	2.80	2.80
A. Changes in Forest and Other Woody Biomass Stocks		NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Forest and Grassland Conversion		NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Abandonment of Managed Lands		NA	NA	NA	NA	NA	NA	NA	NA	NA
D. CO_2 Emissions and Removals from Soil		NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Other		3.50	4.50	4.20	4.20	2.40	3.50	2.80	2.80	2.80
6. Waste	0.00	2.98	3.01	3.06	3.10	3.14	3.17	3.21	3.25	3.25
A. Solid Waste Disposal on Land		NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Wastewater Handling		2.81	2.84	2.88	2.92	2.95	2.99	3.03	3.06	3.06
C. Waste Incineration		0.17	0.17	0.18	0.18	0.18	0.18	0.19	0.19	0.19
D. Other										
7. Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Memo Items:										
International Bunkers	0.00	0.70	0.70	0.73	0.66	0.71	0.74	1.90	1.90	0.83
Aviation		0.27	0.24	0.26	0.24	0.24	0.26	1.14	1.14	0.28
Marine		0.44	0.45	0.46	0.41	0.47	0.48	0.76	0.76	0.55
Multilateral Operations										
CO_2 Emissions from Biomass										

Canada
1998
Submission 2000

Table 3.A.2 Emissions Trends (HFCs, PFCs and SF_6) – (Sheet 4 of 5)*

Greenhouse Gas Source and Sink Categories	Base year[1]	1990	1991	1992	1993 (Gg)	1994	1995	1996	1997	1998
Emissions of HFCs[2] - CO_2 equivalent (Gg)	0.00	0.00	0.00	0.00	0.00	0.00	479.41	885.95	864.07	864.07
HFC-23							0.00	0.00	0.00	0.00
HFC-32							0.00	0.00	0.00	0.00
HFC-41								0.00	0.00	0.00
HFC-43-10mee								0.00	0.00	0.00
HFC-125							0.02	0.03	0.05	0.05
HFC-134								0.00	0.00	0.00
HFC-134a							0.28	0.54	0.41	0.41
HFC-152a							0.00	0.02	0.04	0.04
HFC-143								0.00	0.00	0.00
HFC-143a							0.01	0.02	0.04	0.04
HFC-227ea							0.01	0.01	0.00	0.00
HFC-236fa								0.00	0.00	0.00
HFC-245ca								0.00	0.00	0.00
Emissions of PFCs[2] - CO_2 equivalent (Gg)	0.00	5 975.11	6 318.31	6 600.45	7 399.29	6 912.47	6 015.90	5 878.68	5 962.64	6 023.16
CF_4		0.81	0.87	0.90	1.02	0.95	0.83	0.81	0.82	0.83
C_2F_6		0.07	0.08	0.08	0.09	0.08	0.07	0.07	0.07	0.07
C_3F_8										
C_4F_{10}										
c-C_4F_8										
C_5F_{12}										
C_6F_{14}										
Emissions of SF_6[3] - CO_2 equivalent (Gg)	0.00	2 870.39	3 260.37	2 172.51	2 009.99	2 037.00	1 879.26	1 362.30	1 390.19	1 536.2
SF_6		0.12	0.14	0.09	0.08	0.09	0.08	0.06	0.06	0.06

Chemical	GWP
HFCs	
HFC-23	11 700
HFC-32	650
HFC-41	150
HFC-43-10mee	1 300
HFC-125	2 800
HFC-134	1 000
HFC-134a	1 300
HFC-152a	140
HFC-143	300
HFC-143a	3 800
HFC-227ea	2 900
HFC-236fa	6300
HFC-245ca	560
PFCs	
CF_4	6 500
C_2F_6	9 200
C_3F_8	7 000
C_4F_{10}	7 000
c-C_4F_8	8 700
C_5F_{12}	7 500
C_6F_{14}	7 400
SF_6	23 900

Table 3.A.2 Emissions Trends (All Gases) (Sheet 5 of 5)*

Greenhouse Gas Source and Sink	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998
					CO_2 equivalent (Gg)					
Net CO_2 emissions/removals	0.00	426 614.35	399 099.71	424 187.10	433 459.92	452 330.20	472 712.28	477 668.84	494 751.19	507 597.87
CO_2 emissions (without LUCF)(6)	0.00	465 755.39	456 369.09	469 538.64	468 038.53	482 059.00	493 840.82	506 554.60	518 376.10	529 430.87
CH_4	0.00	74 376.36	77 047.14	79 565.43	82 237.17	84 387.15	87 413.90	90 177.77	90 663.53	89 479.55
N_2O	0.00	62 792.66	62 623.36	62 653.72	64 149.03	68 346.41	69 144.45	71 749.44	70 025.77	64 893.77
HFCs	0.00	0.00	0.00	0.00	0.00	0.00	479.41	885.95	864.07	864.07
PFCs	0.00	5 975.11	6 318.31	6 600.45	7 399.29	6 912.47	6 015.90	5 878.68	5 962.64	6 023.16
SF_6	0.00	2 870.39	3 260.37	2 172.51	2 009.99	2 037.00	1 879.26	1 362.30	1 390.19	1 536.21
TOTAL (with net CO_2 emissions/removals)	0.00	572 628.87	548 348.89	575 179.21	589 255.40	614 013.23	637 645.20	647 722.99	663 657.40	670 394.64
TOTAL (without CO_2 from LUCF)(6)	0.00	611 769.91	605 618.27	620 530.75	623 834.02	643 742.03	658 773.75	676 608.75	687 282.30	692 227.64

Greenhouse Gas Source and Sink Categories	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998
					CO_2 equivalent (Gg)					
1. Energy	0.00	467 703.30	459 751.87	477 484.45	477 276.88	493 260.97	507 751.30	522 906.63	535 012.43	545 128.31
2. Industrial Processes	0.00	53 065.08	53 853.20	52 621.26	54 152.53	56 469.05	56 347.30	58 455.04	57 288.04	52 325.27
3. Solvent and Other Product Use	0.00	418.69	423.65	430.02	436.02	440.65	446.05	451.43	456.30	456.96
4. Agriculture	0.00	68 048.49	67 676.37	65 947.70	67 483.29	70 146.89	70 139.17	70 957.82	70 186.08	69 501.29
5. Land-Use Change and Forestry(7)	0.00	-36 676.34	-54 066.28	-42 464.03	-31 752.01	-28 205.70	-19 048.14	-27 142.06	-21 881.21	-20 089.30
6. Waste	0.00	20 069.64	20 710.08	21 159.82	21 658.69	21 901.38	22 009.52	22 094.13	22 595.76	23 072.11
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(1) Fill in the base year adopted by the Party under the Convention, if different from 1990.

(2) See footnote 4 to Summary 1.A of this common reporting format.

(3) Take the net emissions as reported in Summary 1.A of this common reporting format. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

(4) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO_2 emissions and removals from Land-Use Change and Forestry.

(5) Enter information on the actual emissions. Where estimates are only available for the potential emissions, specify this in a comment to the corresponding cell. Only in this row the emissions are expressed as CO_2 equivalent emissions in order to facilitate data flow among spreadsheets.

(6) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO_2 emissions and removals from Land-Use Change and Forestry.

(7) Net emissions.

NA – not applicable
NE – not estimated
NI – not inventoried
NO – not occuring

* These tables were extracted from Canada's Greenhouse Gas Inventory 1990-1998: Final Submission to the UNFCCC Secretariat, Volume 2 of 2, Environment Canada, Ottawa, August 2000. The updated 1999 GHG inventory data is published in Canada's Greenhouse Gas Inventory 1990-1999: Common Reporting Format Tables, Environment Canada, Ottawa, April 2001. Electronic (PDF) and hard copies can be requested at the following e-mail address: ghg@ec.gc.ca

CHAPTER 4 Policies and Measures

INTRODUCTION

Canada's federal, provincial, and territorial orders of government have been addressing the challenge of climate change for more than a decade. The cornerstone of earlier efforts was the 1995 National Action Program on Climate Change (NAPCC), a framework designed to address the issue in response to Canada's 1992 ratification of the United Nations Framework Convention on Climate Change (UNFCCC). The NAPCC provided for a three-pronged approach: mitigating greenhouse gas (GHG) emissions, improving our scientific understanding of the issue, and taking action to adapt to potential climate change. Under the parameters of the NAPCC, governments have carried out their own programs and supported projects by the private sector and non-governmental organizations (NGOs).

In October 2000, at a Joint Meeting of Energy and Environment Ministers, Canada's National Implementation Strategy on Climate Change (NIS) and First National Climate Change Business Plan (FNBP) were released. They are significant steps forward in addressing climate change and building upon key overarching principles. The NIS provides a framework (a shared risk management approach) to develop strategies on climate change, while the FNBP outlines specific initiatives. Business plans will be updated annually on a three-year basis.

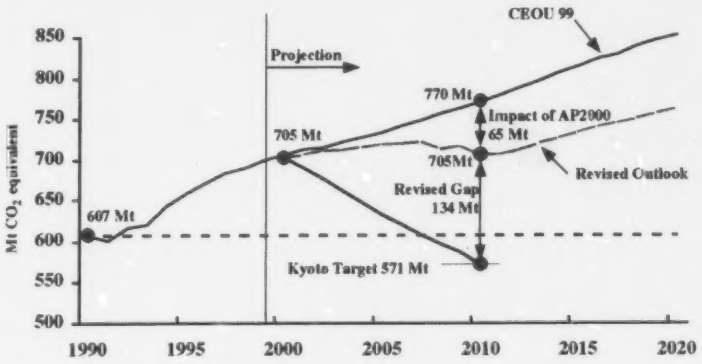
Measures in the Government of Canada's Action Plan 2000 on Climate Change, a component of the broader FNBP, are projected to reduce Canada's GHG emissions by about 65 Mt annually during the Kyoto Protocol's 2008–2012 commitment period. Action Plan 2000, announced in October 2000, provides for $500 million in funding over five years to help achieve Canada's emissions target (see Chapter 5 for more details on the breakdown). The projected reductions would cover about one-third of the gap between Canada's projected emissions in that year and its Kyoto target (Figure 4.1). Canada's commitment under the Kyoto Protocol is to reduce anthropogenic GHG emissions to 6% below 1990 levels during the 2008–2012 commitment period.

As of December 2000, there were a total of about 665 policies and measures (P&Ms) implemented or planned by federal, provincial, and territorial governments directly related to climate change, as outlined in *A Compendium of Canadian Initiatives: Taking Action on Climate Change* and in the FNBP. There are also hundreds of other P&Ms at all orders of government that have an indirect yet positive impact on reducing GHG emission levels.

In Canada, the production and consumption of energy from fossil fuels are responsible for 80% of anthropogenic GHG emissions. Fossil fuels play a critical role in transportation, electricity generation, industrial and manufacturing production processes, and commercial, residential, and institutional heating, cooling, and ventilation systems. Canada is a leader in promoting sustainable energy development both domestically and internationally and has pursued the objectives of improving energy efficiency and moving toward less carbon-intensive fuels. In its November 2000 report entitled *Dealing with Climate Change: Policies and Measures in IEA Member Countries, the International Energy Agency (IEA)* analyzed and compared energy-related P&Ms pertaining to climate change and GHG emissions in IEA member countries. This report indicates that as of 1999 (prior to the October 2000 release of Canada's FNBP and Action Plan 2000 measures), Canada had the highest number of planned and implemented energy-related P&Ms among the IEA's 26 member countries, with a total of 153 P&Ms (135 implemented and 18 planned). These energy-related P&Ms are included in the 665 total. Canada's energy-related P&Ms cover both sector-specific activity (e.g., transport, electricity, industry) and broader framework policy areas (e.g., fiscal, regulatory, research and development [R&D]).

In addition to the more than 600 planned and implemented P&Ms highlighted above, many of the municipal governments in Canada, of which there are over 5 000, have undertaken an array of climate change actions at the local level in areas such as municipal buildings, energy use, landfills, recycling, and forest sink initiatives. The Federation of Canadian Municipalities (FCM) is

Figure 4.1 Revised Update: Total GHG Emissions and Kyoto Target



Note: This chart does not capture the full impact of the FNBP (to be determined). See Chapter 5 for further details.

considering developing an inventory of these actions. Canada's private sector also actively engages in the climate change issue by registering with the Voluntary Challenge and Registry Inc. (VCR) program,[29] a not-for-profit organization established in 1994 to provide, through leadership, the means for promoting, assessing, and recognizing the effectiveness of the voluntary approach in addressing climate change. Registered companies must submit an Action Plan detailing how they intend to reduce their GHG emissions and must undergo independent review and public reporting on the progress of promised reductions. To date, a total of over 750 companies and NGOs, responsible for more than 75% of Canada's GHG emissions, have registered with VCR, and over 170 have registered with the Quebec program, ÉcoGESte.

NATIONAL CLIMATE CHANGE PROCESS

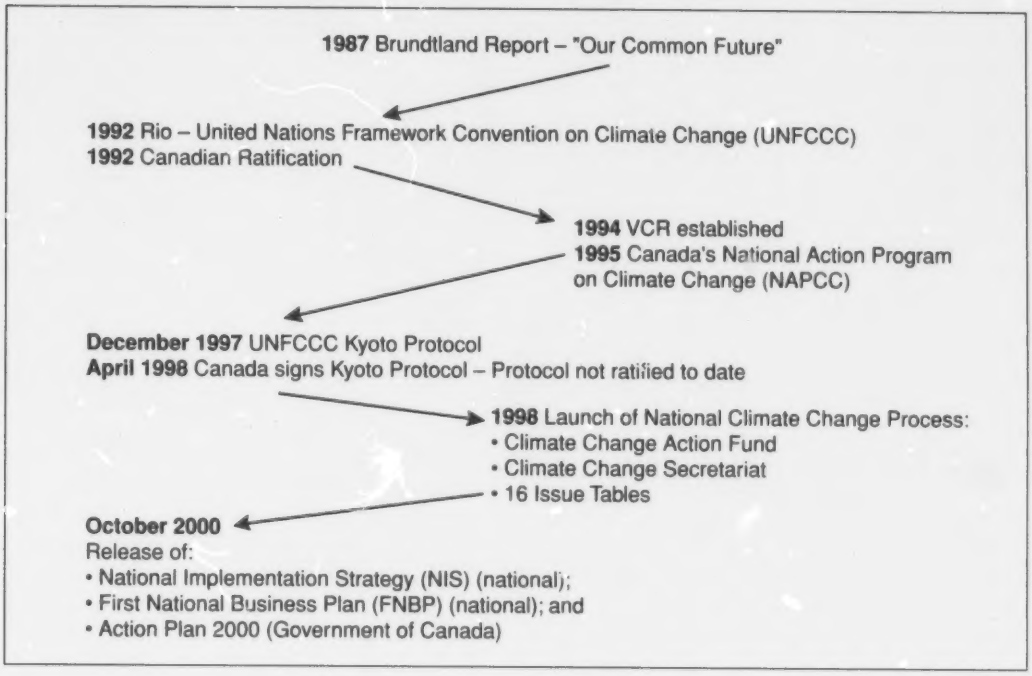
After the publication of Canada's Second National Report on Climate Change in 1997, Canada's federal, provincial, and territorial governments instituted a broad participatory National Climate Change Process (NCCP). As outlined in Chapter 2, Canada's governing structure and division of powers, particularly in relation to implementing policies on natural resources and the environment, necessitate a high degree of cooperation. The NCCP directly followed upon Canada's April 1998 signing of the Kyoto Protocol.

The Prime Minister, provincial premiers, and territorial leaders directed their energy and environment ministers to examine the impacts, costs, and benefits of implementing the Kyoto Protocol, as well as options for addressing climate change, in advance of a decision on ratification. To achieve these broad goals, the NCCP was mandated to consult stakeholders, evaluate mitigation and adaptation options, and produce a national strategy. Ministers agreed that the deputy minister–level National Air Issues Steering Committee (NAISC) would be responsible for managing the development of the national response and providing advice, based on the work of the National Air Issues Coordinating Committee — Climate Change (NAICC-CC), which operates at the assistant deputy minister level.

Also key to the process was the establishment of the Climate Change Secretariat (CCS). The CCS is composed of federal officials supporting the efforts of the Government of Canada (federal ministers) and a separate

29 In Quebec, this program is administered by the provincial government under the name "*Programme québécois d'enregistrement des mesures volontaires sur les changements climatiques*" and is referred to as "ÉcoGESte."

Figure 4.2 Timeline for Canada's Climate Change Activity


1987 Brundtland Report – "Our Common Future"
1992 Rio – United Nations Framework Convention on Climate Change (UNFCCC)
1992 Canadian Ratification
1994 VCR established
1995 Canada's National Action Program on Climate Change (NAPCC)
December 1997 UNFCCC Kyoto Protocol
April 1998 Canada signs Kyoto Protocol – Protocol not ratified to date
1998 Launch of National Climate Change Process:
• Climate Change Action Fund
• Climate Change Secretariat
• 16 Issue Tables
October 2000
Release of:
• National Implementation Strategy (NIS) (national);
• First National Business Plan (FNBP) (national); and
• Action Plan 2000 (Government of Canada)

national group comprising federal, provincial, and territorial officials. The national group supports the ongoing work of the NAICC-CC in its policy, analytical, and program development activities and monitors the progress of intergovernmental initiatives.

In 1998, the NCCP established 16 Issue Tables (Working Groups) involving 450 experts from industry, academia, NGOs, and government. These Issue Tables/Working Groups examined emissions reduction options in the following areas: transportation, electricity, Kyoto Protocol mechanisms, technology, carbon sinks, credit for early action, public education and outreach, agriculture and agri-food, the forest sector, buildings, industry, enhanced voluntary action, municipalities, science and adaptation, and tradeable permits.

Each Issue Table produced two papers: a Foundation Paper analyzing the current status of the respective sector and issue and an Options Report setting out a range of short-, medium-, and long-term options, taking into consideration emissions reduction potential, opportunities and barriers, implementation time frames, competitiveness implications, and social, economic, environmental, and health costs and benefits. The work of the Issue Tables/Working Groups served as the basis for Canada's NIS and FNBP, copies of which can be found on the NCCP Web site (www.nccp.ca). Figure 4.2 sets out the timeline for Canada's climate change activity.

The work of the Issue Tables/Working Groups was funded through a portion of the $150 million three-year Climate Change Action Fund (CCAF) established in 1998 to build a policy foundation and to initiate early action to address climate change. The CCAF also funded research into climate science, impacts and adaptation, technology early action measures, and public education and outreach. The federal budget of February 2000 announced the extension of the CCAF until fiscal year 2003–2004.

National Implementation Strategy on Climate Change

Canada's NIS is a framework for a coordinated, comprehensive, and phased approach across

jurisdictions to address the issue of climate change and to reduce the uncertainties to the extent possible. The NIS involves:

- taking immediate action to reduce risk and to improve our understanding of the risks associated with climate change, as well as of the costs and consequences of reducing emissions and adapting to a changing environment;
- instituting a national framework that includes individual and joint action and that recognizes jurisdictional flexibility in responding to unique needs, circumstances, and opportunities;
- adopting a phased approach, which schedules future decisions and allows progressive action in responding to changing domestic and international circumstances and improved knowledge;
- improving our understanding of the functioning of the climate system and the national and regional climate change impacts as they affect Canada, in order to take actions to reduce emissions and adapt to a changing environment;
- understanding the necessary relationship between international and national strategies;
- developing our understanding of the implications of various emissions reduction policy options, including cross-cutting policy approaches such as emissions trading before making decisions about targets or moving to the next phase; and
- establishing an integrated national "business planning" process, which will serve as the primary mechanism for setting clear objectives, identifying specific actions to be undertaken, identifying further actions for consideration, and reporting on progress.

The five major themes for Phase One of the NIS are the following:

- enhancing awareness and understanding (focusing on public awareness);
- promoting technology development and innovation;
- governments leading by example;
- investing in knowledge and building the foundation (enhancing data collection, inventories, modelling, analytical capacity, and policy development); and
- encouraging action (including sectoral, cross-sectoral, and cross-cutting action).

First National Climate Change Business Plan and Action Plan 2000 (October 2000)

The NIS outlines an annual business planning cycle that focuses on the strategic priorities to address climate change. The FNBP, as the first business plan under Phase One of the NIS, builds on more than a decade of action on climate change by all jurisdictions. The FNBP contains federal, provincial, and territorial actions to address climate change across a number of sectors. Many of these P&Ms are applicable to a combination of jurisdictions, leading to partnerships and cooperation. The focus of the NCCP will be to coordinate the implementation of these FNBP commitments, conducting ongoing policy and analytical work and undertaking future business planning. The FNBP will evolve annually, look forward on a three-year basis, and focus on priority theme areas for the design and development of concrete P&Ms.

The actions outlined in the FNBP focus on mitigation activities planned or under way in a number of different sectors, including electricity, transport, industry, agriculture, forestry, and buildings (residential and commercial). Long-term strategies for mitigation include reducing energy use in all sectors (conservation, energy efficiency), reducing the carbon content of the energy mix (achieving carbon efficiency through fuel switching), the capture and storage of carbon dioxide (CO_2) in geological formations, sequestering carbon through biological processes (sinks), and reducing non-energy sources of emissions (e.g., livestock management). The FNBP undertakes these efforts by outlining various P&Ms built around the five major themes outlined above for the NIS.

The FNBP also sets the strategic direction for actions related to climate science, impacts, and adaptation. The key areas promoted in the

FNBP include P&Ms related to energy efficiency, technology development, strategies for adaptation, public awareness, and continuous reduction in energy and emission intensity.

As part of its contribution to the FNBP, the Government of Canada released its five-year, $500 million Action Plan 2000 on Climate Change. This federal contribution to the FNBP is in addition to previous federal investments outlined in the February 2000 budget, in which more than $600 million over five years was committed to climate change activities. Since 1995, the federal government has spent or committed a total of $1.95 billion on initiatives related to climate change. (For information on Action Plan 2000, see www.climatechange.gc.ca.)

The provinces and territories have contributed a substantial number of initiatives to the FNBP, but no estimate has been made of the potential emissions reductions. Some FNBP initiatives may also be difficult to measure, as they are laying the groundwork for future initiatives.

Monitoring and reporting progress are key components of Canada's national response to climate change. When Canada's ministers of energy and environment released the FNBP in October 2000, they committed to ongoing monitoring of progress against the overarching objectives and themes set out and to reporting these findings to stakeholders and the general public. The Progress Report on Canada's First National Climate Change Business Plan was released in September 2001 (for further information, see www.nccp.ca). As a signatory to the UNFCCC, Canada is obligated to periodically report on its national inventory of anthropogenic GHG emissions and the progress of policies and actions to reduce such emissions (see Chapter 3 for more details).

A Compendium of Canadian Initiatives: Taking Action on Climate Change (October 2000)

Since 1997, a variety of non-NIS and non-FNBP climate change measures affecting key sectors have been implemented, adopted, or proposed. Some key P&Ms outlined in the 1997 report are still ongoing, such as the VCR.

In October 2000, *A Compendium of Canadian Initiatives: Taking Action on Climate Change* was released along with the NIS and FNBP. It is broken down by key sector under the five themes of the NIS and encompasses a wide variety of activity, such as promoting fuel efficiency and alternative energy usage, technological development, and retrofitting buildings. (For further information, see www.nccp.ca.)

GHG EMISSIONS REDUCTION CHALLENGES

Canada's GHG emissions in 1999 were equivalent to 699 Mt of carbon dioxide. This figure is 15% higher than the 1990 level of 607 Mt and 21.6% higher than Canada's Kyoto target of 571 Mt (6% below 1990 levels). Canada's GHG emissions are projected to be 770 Mt in 2010 in the absence of new (post-1999) initiatives in Canada. On this basis (pre–Action Plan 2000 measures), Canada would face the challenge of reducing its emissions by 26% by 2010 to achieve its Kyoto target. (See Chapter 5 for more details on projections.)

As outlined in Chapter 2, Canada faces numerous inherent challenges in controlling growth in secondary energy use and reducing GHG emissions as a result of climate, geography, having an export-oriented economy, and possessing significant levels of natural resources for production and export. These challenges will likely be exacerbated by the projected:

- continuing economic growth and increases in consumer and business activity levels;
- increases in domestic and foreign demand for Canadian oil and natural gas;
- further expansion in global trade;
- ever-increasing requirements for "just-in-time" delivery of commodities for businesses and the resulting trend away from the more energy-efficient rail to truck transport;
- move to more energy-intensive economic activity and components of the Canadian economy; and
- increases in population mainly due to high immigration levels.

The result is likely higher GHG emissions in future years in areas such as fossil fuel production (which represents more than half of the projected growth in GHG emissions to 2010 — largely a result of export demand), increases in Canadian transportation energy consumption, and, finally, increasing usage of both coal and natural gas for electricity generation to meet increasing consumer and business demand.

POLICIES AND MEASURES

The Intergovernmental Panel on Climate Change (IPCC) has stressed the underlying importance of national circumstances in determining the appropriate mix of P&Ms.[30] Appropriate P&Ms, therefore, reflect the widely differing institutional, social, economic, technical, and natural resource endowments in individual countries and regions. Based upon the principles and strategic directions outlined in the FNBP, and utilizing the five themes of the NCCP, key broad-based actions on climate change since Canada's last National Report (1997) are identified below.

The examples provided represent P&Ms on climate change that Canadian governments either have implemented or are in the process of implementing. For a more comprehensive listing of the P&Ms currently planned or adopted by governments — and a number of activities and initiatives by the private sector (VCR/ÉcoGESte) and municipalities (FCM) — see Appendix 1, Table 1 ("Summary of Policies and Measures Affecting GHGs by Sector").

The P&Ms outlined in this Third National Report do not include an estimation of GHG reductions. It is expected that as several of the actions in this report (and the FNBP) are fully implemented and their results are reported, some estimates of impacts will be provided. However, the interaction of measures, data constraints, and the difficulty of separating the influence of individual policies and measures from that of other orders of government or other agencies (e.g., electrical and natural gas utilities) do not allow for estimates of GHG reductions on an individual P&M basis.

Nevertheless, looking at changes in the principal factors that influence energy use and related GHG emissions in the main sectors of the Canadian economy can provide an understanding of the influence of the various efforts to address climate change. The Government of Canada's Office of Energy Efficiency (OEE), part of Natural Resources Canada (NRCan), has developed some notable indicators on changes in energy use at the secondary level. OEE also provides a comprehensive and detailed presentation of energy trends and energy-related GHG emissions by sector that can be found in *Energy Efficiency Trends in Canada 1990 to 1999 — An Update*. This information places Canada among the world leaders in producing this type of analysis. Table 4.1 presents the impacts that the changes in activity, structure, weather, and energy efficiency had on secondary energy use in 1999.

Key conclusions from this analysis indicate that Canada's efforts in promoting energy efficiency have played an important role in limiting the growth in secondary energy use[31] and related GHG emissions compared with what they would have been otherwise. As Figure 4.3 indicates, overall energy efficiency improved by about 8% in Canada between 1990 and 1999. Various P&Ms, ranging from promoting technological investments and R&D to the development of standards for industrial and building codes, play an important role in these efforts.

In the absence of important energy efficiency improvements, GHG emissions from secondary energy use would have been around 32.2 Mt higher in 1999 than in 1990. From another viewpoint, had energy consumption remained at 1990 levels — secondary energy use increased 12.2% between 1990 and 1999 — GHG emissions would have been about 49 Mt lower in 1999 than actual levels owing to energy efficiency efforts. These energy efficiency achievements occurred in the face of Canada's 24.8% aggregate growth rate in gross domestic product (GDP) during the same period. (See Chapter 3 for more details.) In addition to GHG emissions reductions, the improvement in energy efficiency saved Canadians about $5.7 billion in energy

30 IPCC (1996). Technical Paper on Technologies, Policies and Measures for Mitigating Climate Change. 1, p. 5.

31 Secondary energy use is the energy used by Canadians to heat and cool their homes and workplaces and to operate their appliances, vehicles, and factories.

Table 4.1 Factors Influencing Growth in Secondary Energy Use, 1990–1999

Sectors	Energy Use (PJ) 1990	1999	1999 less 1990	Activity Effect (PJ)	Structure Effect (PJ)	Weather Efficiency Effect (PJ)	Energy Effect (PJ)	Interaction Effect (PJ)	Other (PJ)
Residential	1318	1335	17.3	240.9	16.9	-36.0	-171.8	-32.7	n.a.
Commercial	867	984	116.6	136.0	1.284	-2.8	-13.4	-3.0	-1.6
Industrial	2755	3069	313.9	759.6	-74.2	n.a.	-251.6	-119.9	n.a.
Transportation	1878	2258	380.5	365.3	138.3	n.a.	-123.0	-11.5	11.4
Passenger	1166	1323	157.15	150.0	46.6	n.a.	-44.1	15.1	-10.5
Freight	659	860	201.51	215.3	91.7	n.a.	-78.9	-26.6	0.0
Off-Road Motor Gasoline	53	75	21.84	n.a.	n.a.	n.a.	n.a.	n.a.	21.8
Agriculture	199	230	30.8	n.a.	n.a.	n.a.	n.a.	n.a.	30.8
Total	**7016.4**	**7875.4**	**859.0**	**1501.8**	**82.3**	**-38.8**	**-559.8**	**-167.1**	**40.6**

n.a. = not available.

The change in energy use between 1990 and 1999 shown in this chart and the sum of the activity, structure, weather, energy efficiency, and interaction for passenger and freight transport are slightly different because of the exclusion from the factorization analysis of the non-airline segments in passenger transport. The transport sector differences are reflected at the secondary energy use level; other differences are excluded from the factorization, such as agriculture, off-road motor gasoline, and street lighting, which are included in the "Other" column.

costs in 1999. Details on the contribution of energy efficiency efforts to reductions in GHG emissions in the various sectors of the economy are provided throughout the remainder of this chapter.

The following sections highlight the range of P&Ms, recently initiated under the five themes of Phase One of the NIS, that build upon these energy and related climate change efforts and successes of the past.

Enhancing Awareness and Understanding (EAU)

Enhancing awareness and understanding (EAU) measures are focused on:

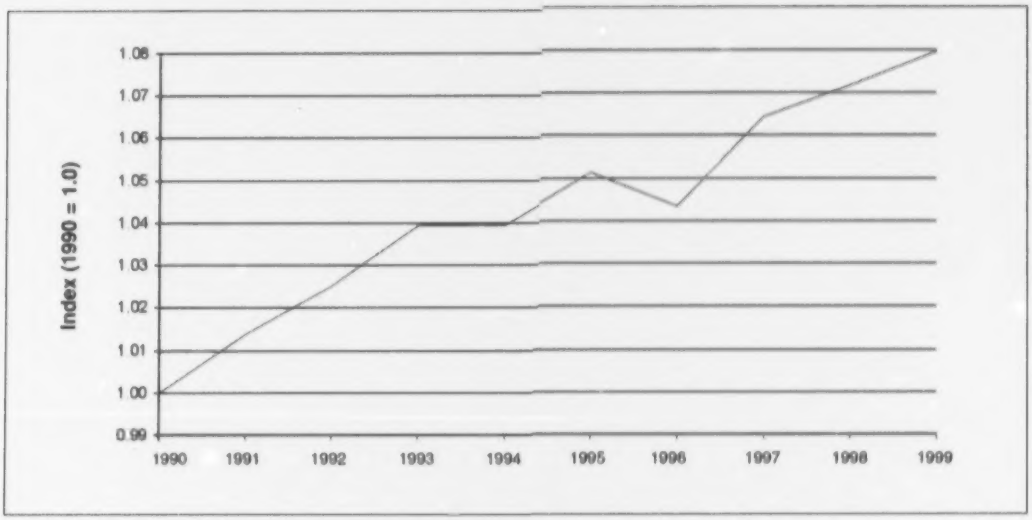
- building awareness and understanding among Canadians of climate change, including the science, impacts, and adaptation and associated environmental, economic, and social issues;
- developing support from Canadians for policy changes and actions that will be required as part of the NIS; and
- encouraging and motivating Canadians to take personal and corporate action to reduce GHG emissions.

Implementation of EAU activities is primarily through a national network of regional centres, or hubs, that will bring together all stakeholders in a province or territory to coordinate their public education and outreach activities. A national advisory team will establish baseline public opinion research against which to measure progress, develop a "toolkit" of materials for use by all stakeholders, and provide a national clearinghouse whereby individual hubs can share success stories and lessons learned (see Chapter 9).

Promoting Technology Development and Innovation

Innovative science and technology is a key policy instrument. It provides the knowledge base and technologies for a sustainable future. The Government of Canada believes that technology will play a fundamental role in its ability to successfully address the climate change challenge. The investigation, development, and deployment of a broad range of innovative products and processes are essential to reduce the concentration of GHGs. Canada has a broad range of technology

Figure 4.3 OEE Energy Efficiency Index, 1990–1999



activities that directly and indirectly address the adaptation to, and mitigation of, climate change in the different regions of the country. Canada's goal is the development of a whole range of new technologies and the continuous development of underpinning scientific and technological expertise.

Federal Government In-House Research Capability

The federal government is a key contributor to Canada's efforts to innovate and deploy new technologies. The federal government, through such science-based departments as NRCan, Environment Canada, and Agriculture and Agri-Food Canada, undertakes R&D to address climate change issues. With its strong scientific community and one-of-a-kind research facilities, the Canadian government is working closely with the private sector to address climate change through the introduction of technologies to the market or the development of the next generation of climate change technologies. This in-house research capacity is complemented by a number of funding programs, outlined below.

Technology Early Action Measures (TEAM)

Technology Early Action Measures (TEAM) was established in 1998 as part of the federal government's CCAF initiatives. TEAM is a highly coordinated $60 million federal government–led program that to year 2000 has leveraged around $600 million to support investments in cost-effective technology projects that are designed to lead to significant reductions in GHG emissions. In this process:

- TEAM serves as one of the primary tools for implementing federal climate change policy. It provides for cost-effective public–private partnership and takes the unique approach of incremental financing and extensive networking.
- TEAM has brought together partners within the industry, in communities, and internationally to encourage additional investment and accelerated development of innovative technology across all sectors of the economy.
- As of December 2000, 50 domestic and 17 international partnerships have been approved under TEAM, for a total investment of $700 million. These leveraged investments have been accomplished on the strength of a $60 million investment by TEAM and $59 million from federal delivery programs

that have redirected some of their efforts toward GHG mitigation technology. TEAM's community projects have attracted $232 million in new technology investment by municipalities, Aboriginal communities, and industry. A further $150 million of foreign government and private sector investment in international projects has provided opportunities for Canadian companies. Private industry has committed $200 million to GHG mitigation technology development under TEAM industry projects.

- TEAM has been extended until March 31, 2004.

Climate Change Technology and Innovation Program (Federal–Provincial)

This initiative aims at accelerating the development of cost-effective GHG mitigation technologies in multiple sectors, building the intellectual foundation for long-term technological advances, and building alliances and partnerships to help plan and advance the R&D. The program consists of interrelated short- and long-term measures: (i) *discovery, research and development*, to find and develop new and fundamentally different technology concepts; (ii) *fostering a collaborative approach*, to develop networks and technology roadmapping; and (iii) *technology marketing*, to support the business environment for innovation.

Sustainable Development Technology Fund (Government of Canada)

This initiative focuses on the development and demonstration of climate change and clean air technologies. It complements other research and government efforts in technological innovation, such as those by the National Research Council (NRC), Natural Sciences and Engineering Research Council (NSERC), Program of Energy Research and Development (PERD), Industrial Research Assistance Program, Technology Partnerships Canada, and TEAM.

Program of Energy Research and Development (PERD) (Government of Canada)

For 20 years, PERD has played a strategic R&D role in economically and environmentally sustainable energy technologies. This interdepartmental program supports 38 research areas, including environmental solutions for the oil and gas sector, cleaner transportation for the future, energy-efficient buildings and communities, energy-efficient industry, Canada's electricity infrastructure, and climate change (impacts, adaptation, and natural uptake). PERD works collaboratively with 12 federal departments and agencies, as well as an extensive network of companies industry associations, regulatory agencies, and universities.

Fuel Cell Technology Development (Government of Canada)

The Government of Canada has supported the development of fuel cell and related technologies since 1983. The objective is to reduce emissions from transportation and stationary power applications and further the growth of Canadian industry. In 1999, the government announced the National Fuel Cell Research and Innovation Initiative, funded at $30 million and involving NRCan, NRC, and NSERC. Action Plan 2000, with funding of $500 million, includes funding for a program to develop the fuelling infrastructure for fuel cell vehicles.

Weyburn Carbon Dioxide Injection Monitoring Project — Capture and Storage (Governments of Canada and Saskatchewan)

This monitoring project is a four-year research program (2000–2004) to develop a comprehensive understanding of carbon dioxide injection into oil-bearing geological structures. Through detailed research and measurement, an international research team (IEA-led) will verify the effectiveness of enhanced oil recovery as a method of managing GHG emissions, providing direction and leadership for similar projects in Canada and around the world.

Saskatchewan Petroleum Research Incentive (Government of Saskatchewan)

One of the main purposes of this incentive is to reduce the environmental impact of oil and natural gas production, which includes GHG emissions reduction. The financial support provided by the incentive is in the form of oil and natural gas royalty and tax credits, which enable producers to deduct a portion of their company's approved costs for research from their oil and natural gas royalty and tax payments.

Government Leading by Example (Government Operations)

The Government of Canada and provincial and territorial governments have put in place substantive government-wide initiatives for their respective departments, agencies, and related institutions to undertake GHG emissions reductions. For example, the Government of Canada's own House in Order Initiative has set a target of reducing GHG emissions from its own operations so that emissions will be 31% below 1990 levels by 2010. A 19% reduction has already been achieved since 1990 due to downsizing and normal efficiency efforts. Under the initiative, the Government of Canada will reduce its emissions by a further 12% by 2010. To achieve these reductions, the 11 departments responsible for most of the federal government's GHG emissions are being assigned specific targets and will be required to report annually on their programs.

Emissions reductions in government operations will be achieved through an array of initiatives in areas such as fleet management and alternative fuels, facilities management (e.g., building retrofits), waste management, "green" procurement, and telework and commuting practices. Examples of initiatives include:

- *enhanced federal building and fleet strategies, and a leadership challenge* to engage all federal entities in undertaking and reporting on their own GHG reduction actions (Government of Canada);

- *a green power* purchasing incentive program for the purchase of "green" power (non-GHG emitting) for federal facilities throughout Canada (Government of Canada); and

- *energy improvements in funded buildings (school modernization)* to ensure that retrofits during 2000–2002 achieve high levels of energy efficiency and reduce GHG emissions, with funding coming from a portion of a $170 million fund to improve energy efficiency in school buildings (Government of Alberta).

Investing in Knowledge/Building the Foundation

A key element in generating the core knowledge on climate change was the work of the 16 Issue Tables/Working Groups over a two-year period that began in 1998. The Issue Tables undertook work that led to Foundation Papers that analyzed the current status of their respective issues and sectors and outlined various challenges and opportunities. After the Foundation Papers, members of each Issue Table began sector-specific and cross-cutting analyses of emissions reduction opportunities and barriers and identified reduction and adaptation options for consideration in developing Canada's national strategy on climate change.

Current activities that build upon the work of the Issue Tables include:

- the work of the Analysis and Modelling Group (AMG), which is conducting integrated assessments of the economic and environmental implications for Canada of implementing the Kyoto Protocol (see An Assessment of the Economic and Environmental Implications for Canada of the Kyoto Protocol, Analysis and Modelling Group, November 2000); and

- analytical work on possible domestic and international emissions trading systems in support of market-based mechanisms for GHG reductions.

Encouraging Action (Sectoral Actions)

The private sector across the Canadian economy, with assistance from all orders of Canadian government, has made consistent progress in reducing energy intensity, increasing energy efficiency and productivity, reducing emissions, and exploring new arrangements for reductions. In meeting current and future challenges, federal, provincial, and territorial governments and stakeholders have identified a series of opportunities for GHG emissions abatement within and between sectors of the Canadian economy. The following subsections provide an overview of each sector, including trends in GHG emissions, and highlights key P&Ms to tackle the GHG challenges.

Agriculture Sector

Canada's agriculture sector comprises approximately 250 000 farms, 98% of which are family-owned. Unlike other sectors, the vast majority of emissions are non-energy (non–carbon dioxide) related. Agriculture contributed 9.0% of Canadian anthropogenic

GHG emissions in 1999 (i.e., about 61 Mt CO_2 eq.) from manure, enteric fermentation, crops, and fertilizers. In 1990, the emissions were about 59 Mt CO_2 eq. Emissions from agriculture are primarily nitrous oxide (N_2O) associated with fertilizer and animal manure use and methane (CH_4) associated with cattle and livestock manure.

Canada's current and proposed P&Ms seek to develop new technologies and practices affecting a wide range of GHG emissions in areas such as fertilizer management, livestock systems, and soil management. A key area for ongoing work is the potential for agricultural soils themselves to act as a carbon sink, which could lead to substantive reductions in GHG emissions. Building upon agronomic studies, the major contributions to reductions in GHG emissions are projected to arise from the continuation of several trends in the sector: increased use of no-till land practices, reduced summer fallowing, improved nutrient management, additional land in forage crops, improved efficiency in fossil fuel use, greater use of ethanol, and reduced methane emissions from livestock and manure owing to improved feeds and management practices. The net effect of the trend toward increased fertilizer use on the Prairies requires further study: better fertility will increase plant biomass production and the potential for carbon sequestration, but nitrous oxide emissions will increase. The production of fertilizer, particularly nitrogen fertilizers, requires energy and natural gas as a raw material.

Key P&Ms in the agricultural area include:

- *The Agricultural Environmental Stewardship Initiative (AESI)*: AESI is a three-year (2000–2003) $10 million program that addresses the regional impacts of agricultural practices on water, soil, and air quality, biodiversity, and GHG emissions through education and awareness, technology transfer, and stewardship tools, including environmental clubs, environmental management systems, and land use planning (Government of Canada).

- *Planting shelterbelts*: Expanding the Prairie Farm Rehabilitation Administration's shelterbelt program, consistent with rules to be negotiated under the Kyoto Protocol, and establishing riparian buffers will reduce net GHG emissions, soil erosion, and nutrient runoff into waterways.

- *Soil conservation projects*: These projects have the objective of adjusting agricultural practices to reduce the loss and enhance the productivity of valuable topsoil and optimize nutrient use efficiency. As a result, these projects increase the uptake or reduce the production of GHGs (namely carbon dioxide, nitrous oxide, and methane) and improve both water and air quality in the process. Building soil organic matter (carbon sequestration) and reducing soil erosion and nutrient losses are the main focuses. Practices include reduced tillage, zero-till, field shelterbelts, grass strips, strip cropping, etc. (Province of Saskatchewan).

- *Sinks*: Net GHG emissions from Canadian agriculture are expected to decrease slightly as a result of the increased use of a number of economically viable practices and measures that mitigate GHG production and enhance soil sinks. Agricultural soils are expected to function as a net sink by 2010 due to decreases in summer fallow, increases in no-till farming, increased fertilizer use efficiency, and the conversion of some annual croplands to grasslands. Some studies predict that with appropriate and broad changes in land management practices, agricultural (soils) sinks could sequester, as a conservative estimate, 160 Mt of carbon dioxide in 20 years.

Buildings Sector

The buildings sector accounts for over 10% of Canada's GHG emissions and offers an opportunity to improve energy intensity by using more efficient equipment, improving new construction practices, and retrofitting existing buildings. Enhancing public education and outreach are key to achieving these goals.

Residential

The 1999 GHG inventory indicates that residential emissions account for 43 Mt (6%) of Canada's total GHG emissions, but have declined 2.2% since 1990. Energy efficiency improvements in appliances, in heating equipment, and in the thermal characteristics of houses contributed to

a decline in energy use in the residential sector between 1990 and 1999. Likewise, a relatively warm winter in 1999 contributed to reduced residential energy use. As a result, energy-related GHG emissions from this sector and associated electricity-related GHG emissions were 9.0 Mt lower in 1999 than they would have been. However, both of these declines were offset by upward pressure on residential energy use due to a significant growth in activity (more houses and increased floor area).

Ownership of single detached dwellings in suburbs has become a general cultural norm in Canada, and this type of housing typically requires more energy per square metre than other housing types. New houses also tend to be bigger than the older houses they are replacing. This is especially true of single detached houses, which account for 57% of Canadian households. Single detached dwellings built during 1996–1997 were 31% bigger than those built before 1946 and 49% bigger than those built during the 1946–1960 period. The trend is also to larger domestic appliances. For instance, the average size of refrigerators recently sold in Canada was about 17.1 cubic feet, 10% larger than in 1990. However, this tendency to purchase larger appliances is counterbalanced by the fact that the appliances are more energy efficient.

Commercial

The 1999 GHG inventory indicates that the commercial and institutional sector of the economy accounts for about 28.9 Mt (4%) of Canada's total GHG emissions. Emissions from the commercial and institutional sector increased 12% between 1990 and 1999.

Improved energy efficiency, combined with more moderate weather conditions, helped offset the effect of increased commercial activity between 1990 and 1999, limiting growth in the sector's energy use to 13.4%. Without the advances made in the energy efficiency of commercial and institutional buildings, heating and cooling equipment, lighting technology, electric motors, and control systems, energy use in the sector would have increased 15.0% between 1990 and 1999, and GHG emissions would have been 0.7 Mt higher in 1999 than they were.

Key P&Ms in the buildings sector include:

- *Green Building Retrofit Program*: This program provides an opportunity for provincially funded schools, universities, colleges, and health care institutions to upgrade existing facilities with energy and water efficiency enhancements, as well as waste-saving measures. Since the late 1970s, British Columbia has reduced energy consumption in targeted buildings by over 55% and generated over $120 million in total energy savings through retrofitting provincial facilities (Government of British Columbia).

- *EnerGuide for Houses Program*: Funding of $3 million per year over three years (1998–2001) has been allocated to the EnerGuide for Houses Program, which encourages Canadians to improve the energy performance of their homes (the program has been extended to 2006). Homeowners receive advice from independent energy efficiency experts on how to improve home comfort and reduce heating and cooling costs when making home improvements (Government of Canada).

- *Renewable Energy Deployment Initiative (REDI)*: REDI provides $12 million over three years (1998–2001) to promote renewable energy systems for space and water heating and for cooling through an incentive that funds 25% of the cost of adopting new systems (to a maximum of $50 000). Eligible systems include solar air heating, solar water heating, and high-efficiency/low-emission biomass combustion. REDI also provides market support for earth energy systems and supports pilot projects in the public institution and residential markets (Government of Canada).

- *Commercial Building Incentive Program*: Funding of $10 million per year (1998–2001) has been allocated to provide incentives that encourage building owners and developers to incorporate energy-efficient technologies and practices into designs for new commercial and institutional buildings. To qualify, a design must demonstrate that the new building will be at least 25% more efficient than a reference building that

complies with the Model National Energy Code for Buildings (Government of Canada).

- *Provincial Buildings Initiative (PBI)*: The goal of the PBI is to improve energy efficiency in government-owned buildings. The initiative uses energy performance contracting as a delivery mechanism. All government facilities that are directly funded are being considered for improvements. Efficiency improvements include physical retrofits, training, and awareness activities. PBI efficiency improvements began in November 1997 and are expected to be complete by December 2001. Over 95% of all government buildings have been considered under the initiative, resulting in $26 million in retrofit contracts in 370 buildings. Annual energy savings of $4.5 million are expected. The impacts of the initiative will be monitored over the next 10 years (Government of New Brunswick).

- *Federal Buildings Initiative (FBI)*: The FBI is designed to help an organization manage energy costs while making facilities more comfortable and productive places to work. The FBI provides a full range of products and services required by an organization to implement comprehensive energy efficiency improvements. These include information, advice, and consultation on the organization's readiness and project design, lists of energy management firms qualified to build projects, project financing options, a national network for energy management training, model tendering documents, and employee awareness products. The FBI supports partnerships with energy management firms that provide a turnkey service that includes engineering, third-party private sector financing, comprehensive training packages, and performance guarantees. By March 2000, federal government departments had utilized $180 million of private sector investment to implement FBI-type energy efficiency improvement projects in some 5 500 buildings. These projects generate $24 million in annual cost savings and reduced GHG emissions by some 128 kt annually based on preliminary estimates.

Electricity Sector

Under the Canadian constitution, electricity is primarily within the jurisdiction of the provinces. The federal role regarding electricity is restricted to nuclear energy and international and interprovincial trade. In most provinces, the industry is highly integrated, with the bulk of the generation, transmission, and distribution provided by a few dominant utilities. Although some of these utilities are privately owned, most utilities are Crown corporations owned by the provinces.

The electric power industry has a significant presence within the Canadian economy. In 1997, approximately 80 000 people were directly employed by the industry. Total revenue for the largest utilities amounted to more than $25 billion in 1999, and revenues from exports were about $1.9 billion. Exports accounted for 8% of Canada's total generation in 1999. Exports are sold primarily to markets in the New England states, New York state, the upper Midwest, the Pacific Northwest, and California. Canada's electricity prices in the residential, commercial, and industrial sectors are generally lower than those of other countries.

The Canadian electricity industry is currently responding to increasing competitive pressures and will likely undergo significant restructuring over the next decade, which may change fuel choices. Responsibility for electricity generation, transmission, and distribution and for markets in Canada generally lies with the provinces; therefore, differing systems, technologies, and GHG reduction capacities have evolved.

The electricity sector is projected to account for 16% of Canada's GHG emissions by 2010. In its VCR submission, the Canadian Electricity Association, representing Canada's electrical utilities, announced planned reductions in emissions from operations of approximately 3 Mt by 2000 as a result of mitigative actions. Discussions on electricity sector covenants to encourage GHG emissions reductions outlined in Action Plan 2000 are currently under way.

Emissions from this sector are growing, and it is estimated they will be 25% above 1990 levels by 2008–2012. To achieve GHG reductions, future emissions growth can be moderated through methods such as:

- the displacement of oil- and coal-fired generation by cleaner and more efficient natural gas– and coal-fired combustion;
- the introduction of policy instruments that increase demand and supply for alternative energy sources; and
- a switch to hydro, nuclear, and renewable energy sources.

Key P&Ms in the electricity sector include:

- *Offset programs*: British Columbia Hydro has committed over $2 million for the purchase of GHG offsets over the 2000–2001 time frame. TransAlta Utilities of Alberta has signed an agreement to purchase up to 2.8 million tonnes of carbon emission credits from farms in the United States.
- *Green power procurement and renewables*: Various provincial and federal efforts are under way to provide opportunities and incentives for the development and purchase of green power by governments. The Government of Canada has a broad commitment to purchase 20% of its electricity requirements from low- or non-GHG-emitting electricity sources.
- *CO_2 Capture and Storage Initiative*: This initiative under Action Plan 2000 includes a measure to create an inventory of suitable source and storage sites, including oil and gas reservoirs, coal deposits, and saline aquifers, for their potential to store carbon dioxide captured from coal-fired electricity generation facilities.
- *Efficient energy use*: Various programs monitor and audit energy use by customers, promote secondary energy purchases from hydroelectric generating stations, and promote public awareness and outreach.

Forest Sector

Canada's forests cover 45% of the country's land base and support a wide range of industrial, commercial, cultural, and recreational uses, all of which may be affected by climate change. In particular, much of Canada's forests will likely be altered in character and geographic distribution. Furthermore, climate change is expected to lead to an increase in natural disturbances (e.g., forest fires and insect and disease outbreaks).

Key Canadian P&Ms in the forest sector include:

- *Feasibility assessment of afforestation for carbon sequestration*: The Government of Canada (Canadian Forest Service [32]) is developing a three-year preparatory measure that focuses on assessing, planning, designing, and evaluating the feasibility of a large-scale afforestation program in Canada. As a means to assess the design, mechanics, and feasibility of developing a large-scale program, afforestation pilots, or trials, will be identified across the range of suitable lands in Canada. The primary target group for the afforestation pilots is private landowners with marginal agricultural land.
- *SaskPower Carbon Offset Agreement*: This forest-based carbon offset agreement has been submitted to the Greenhouse Gas Emission Reduction Trading (GERT) Pilot for review. It is currently being evaluated for possible registration in the pilot. The Agreement has two components. One involves planting 5 million seedlings on about 3 300 ha of land over 1999–2002. This land was harvested several decades ago but has not successfully regenerated. The second component is the establishment of approximately 225 000 ha of forest carbon reserves in 1999–2000, removing these areas of provincial forest from harvesting. These actions are intended to generate carbon credits through reforestation and protection from harvesting. The Government of Saskatchewan is transferring these credits to SaskPower in exchange for funding to carry out the afforestation. Credits equivalent to approximately 6 million tonnes of carbon will be transferred.
- *Afforestation and Reforestation Initiative*: Under an afforestation component of its private land silviculture program, New Brunswick expects to plant 500 ha of abandoned privately owned farmland per year. With respect to Crown land, land having less than 60% regeneration stocking after harvesting will be planted.

32 The Canadian Forest Service is part of NRCan.

This Crown land reforestation initiative will see about 10 000 ha planted each year (Government of New Brunswick).

Industry Sector

Canada has the most open economy among G7 countries, with trade in goods and services comprising 75% of its GDP. Resource-based industries alone comprise 40% of Canada's exports. The industry sector generally encompasses manufacturing industries, mining, forestry, construction, and the production of fossil fuels.

Industry sector GHG emissions increased 6.6% between 1990 and 1999. Two-thirds of the sector's emissions come from the consumption of energy. These emissions increased 11.4% between 1990 and 1999 as a result of growth in economic activity and a shift to more energy-intensive industries. However, the increase would have been greater if not for a 9.1% improvement in energy efficiency, achieved through the rationalization of operations, the installation of more efficient equipment, and other efforts. Those efforts are estimated to have curbed GHG emissions by 12.4 Mt in 1999 in the sector.

Five natural resource–based industries — mining, petroleum refining, iron and steel, newsprint, and primary production of aluminum — account for around 25% of this sector's GHG emissions. Due to investments in new technologies and energy efficiency, natural resource–based industries are expected to be able to maintain roughly current levels of GHG emissions, despite growing international demand for Canadian goods.

Key P&Ms in the industry sector include:

- *Canadian Industry Program for Energy Conservation (CIPEC)*: CIPEC is a 25-year-old voluntary industry–government alliance that works to identify energy efficiency potential, establish energy efficiency improvement targets, implement and manage energy efficiency improvement programs and projects, report on progress, and celebrate accomplishments. CIPEC includes 35 trade associations, representing over 3 000 companies and 90% of secondary industrial energy demand. Industry members under CIPEC include the following sectors: aluminum, brewery, cement, chemical, dairy, electrical and electronics, fertilizer, food processing, general manufacturing, lime, mining, oil sands, petroleum, pulp and paper, rubber, soft drink, steel, textile, transportation, and wood products. Industries participating in CIPEC recorded an average annual energy efficiency improvement of 1.26% for the period 1990–1998, representing the amount of energy necessary to heat 38% of all Canadian houses in 1998, while at the same time stabilizing energy-related emissions of carbon dioxide. This exceeds CIPEC's goal of a 1% annual improvement in energy intensity between 1990 and 2010.
- *Promotion of enhanced recycling*: This includes development of improved recycling technology (steel, aluminum, magnesium) and practices.

Given the importance of fossil fuel production to Canada's economy and to better explain the policy context for GHG emissions, the production of oil and gas is discussed separately throughout this report.

Fossil Fuel Production — Oil and Gas

Canada's upstream oil and gas sector is roughly a $60 billion industry, which includes $50 billion in exports. The production, transmission, processing, and distribution of fossil fuels contributed more than 100 Mt of GHG emissions in 1999.[33] Over 50% of Canada's oil and natural gas production is exported, mainly to the United States.

A large amount of energy is required to develop and transport these natural resources. A significant pipeline transportation infrastructure is in place for moving Canadian gas, oil, bitumen, synthetic crude, and liquids from other locations in western and northern Canada to local, national, and U.S. markets. GHG emissions associated with the production of fossil fuels (oil and natural gas) for export alone were responsible for around 25% of the growth of Canada's GHG emissions (estimated at more than 20 Mt) between 1990 and 1999. GHG emissions

33 In combination with coal production, the GHG emissions directly attributable to the fossil fuels sector (including pipelines and fugitive emissions) could be calculated to be as high as 134 Mt, based upon the 1999 GHG inventory data.

in this sector are derived from two principal sources:

- fossil fuel use in the exploration, development, production, and transport of crude oil, natural gas, and coal; and
- fugitive emissions (e.g., carbon dioxide and methane) from the production and transport of these raw materials.

VCR submissions from industry and related evidence suggest that significant emission reductions are possible in natural gas and oil production through improved practices and new technologies. Over the next 10 years, more than half of Canadian crude oil production is expected to come from the oil sands. However, with the adaptation of new technologies, oil sands GHG emissions on a per unit basis of production were reduced by 20% between 1990 and 1999 and are expected to drop another 20% by 2010.

Companies from this sector were founding members of the VCR. Various accomplishments related to energy efficiency improvement and emission reductions are reported in the VCR. Canada's FNBP builds upon these successes, addresses related emissions, such as fugitive GHG emissions, and promotes the storage of carbon dioxide.

Key P&Ms include:

- *Reduction of flaring and venting in the oil and gas sector*: The Clean Air Strategic Alliance (CASA) board of directors has approved a multistakeholder working group to review flaring practices in Alberta and recommend an Alberta venting management framework to improve flaring management and reductions in volumes of solution gas vented into the atmosphere (Government of Alberta).
- *Renewable energy*: This includes a variety of possible projects and funding related to wind, biomass, liquid bio-fuels (e.g., methanol, ethanol), hydroelectricity, solar energy, geothermal energy, etc. (Government of Canada).
- *Adjustments to the Capital Cost Allowance (CCA) system*: The February 2000 federal budget proposes several adjustments to improve the CCA system to encourage investment in energy-efficient manufacturing, electrical, and processing equipment (Government of Canada).
- *Oil and Gas Commission Environmental Fund*: This $400 000 fund was created to explore the feasibility of eliminating emissions (sulphur dioxide and GHG) from flaring and fugitive emissions through development of best management practices and new technology (Government of British Columbia).
- *Carbon dioxide capture and storage*: Analysis and pilot projects (initially in the Western Canadian Sedimentary Basin) will demonstrate the capture, treatment, transportation, and injection of carbon dioxide from large stationary sources (e.g., fossil fuel–based electricity operating stations) for storage in geological formations to prevent the release of carbon dioxide emissions into the atmosphere (Governments of Canada, Alberta, Saskatchewan, and others).

Municipalities

Canada's municipal governments have a direct impact on GHG emissions from their own operations in key areas such as solid waste management (landfills), sewage, buildings and facilities (retrofitting), water and energy systems, transportation (transit, vehicle fleets), and urban planning. Landfill gas, for example, accounts for 26% (1.2 Mt) of all methane emissions in Canada. Overall, municipal governments directly control approximately 6% of Canada's GHG emissions. Municipalities also have an indirect impact on general emissions through their regulatory and planning roles in the community at large. More broadly, municipalities could play a role in over half the national GHG inventory.

Experience over the past 10 years indicates that municipal governments can be effective delivery agents, in partnership with other orders of government, for programs promoting energy efficiency and the reduction of waste and GHG emissions. The goal is to achieve sustainable communities by "reaching, teaching, and equipping" municipalities to undertake these various climate change challenges. The FCM, through its Sustainable Communities program, helps municipal governments target local initiatives that improve the eco-efficiency of their operations.

Key P&Ms include:

- *Climate Change Action Fund (public education and outreach component)*: The Government of Canada provides resources for cost-shared projects, with some funds directed at municipalities. The CCAF is designed to assist municipalities with program delivery and to assist supporting national and regional organizations. One of the projects funded under this category was the FCM's Infrastructure Risk: Adapting to Climate Change project. The project was launched in July 2000 to complement an existing FCM program, the Partners for Climate Protection Program, which promotes the benefits of GHG reductions across 90 participating municipalities (Government of Canada).

- *The Green Municipal Enabling Fund (GMEF) and the Green Municipal Investment Fund (GMIF)*: These are endowment funds that provide support for a variety of municipal infrastructure improvements that benefit the environment, such as the FCM's Sustainable Communities program. The GMEF pays 50% of the cost of feasibility studies, while the GMIF provides loans for up to 25% of the cost of capital projects. Both funds are managed by the FCM, which operates in partnership with the Government of Canada. The five-year, $25 million GMEF supports feasibility studies for innovative environmental projects within municipal operations (e.g., waste management, transportation systems, and renewable energy technologies). The $100 million GMIF provides loans and loan guarantees to eligible recipients to carry out environmental projects within municipal operations as well as grants and long-term loans for pilot projects. Both funds began operating in fiscal year 2000–2001 (Government of Canada).

- *Federation of Canadian Municipalities Municipal Building Retrofit Program*: To advance the adoption of energy efficiency in the municipal sector, the FCM offers municipalities a comprehensive program that includes the elements necessary to identify, develop, and implement comprehensive building energy retrofits, as well as assist in gaining access to financing. Some $1.6 million was provided in the 1999 federal budget (Government of Canada).

- *Landfill gas capture*: Such programs update regulations and management criteria for landfills, including requirements for collection and management of landfill gas, and support the development of local government proposals to utilize landfill gas (Government of British Columbia and regional and local governments). The Municipal Options Report indicates that total landfill capture at 37 sites across Canada is 5.4–6.7 Mt CO_2 eq. annually.

- *Energy audits for municipal buildings*: Energy audits develop the capacity to assist Alberta municipalities in reducing GHG emissions associated with their operations (Government of Alberta).

- *Canada Infrastructure Program*: Through cost-sharing with provincial and municipal partners, this federal program will help accelerate and enhance infrastructure works for local communities. Green municipal infrastructure will be a top priority. The types of investments that would fall under green municipal infrastructure include water, waste management, and efficient energy services (Government of Canada).

- *Landfill standards*: The Ontario government introduced stringent new landfill standards that require the capture of methane emissions. Methane is a GHG 20 times more potent than carbon dioxide. Ontario is one of the first jurisdictions in Canada to enact such a requirement (Government of Ontario).

Transportation Sector

Transportation is a large and diverse sector, accounting for 27% of Canada's GHG emissions in 1999. GHG emissions from the transportation sector increased 24% from 1990 to 1999.

However, energy efficiency improvements in both freight and passenger transportation limited growth in energy use between 1990 and 1999, partially offsetting the growth in vehicle activity and an increase in the amount of freight shipped by truck (a relatively energy-intensive mode of transportation). Without energy efficiency efforts and the ongoing implementation of advanced technologies across the sector, transportation-related GHG emissions would have been 8.9 Mt higher.

The transport sector comprises urban, inter-urban, and rural transportation across a variety of transportation modes and regional systems. The main determinants of road energy demand (and GHG emissions) are the stock of vehicles, their average fuel efficiency, and distance travelled per vehicle. These are, in turn, affected by demographics, geography, economic structure, and levels of economic growth.

The challenges imposed by geography are compounded by continuing growth in the demand for transportation resulting from both population and economic growth. Without further mitigative action, GHG emissions from the transport sector (freight and passenger) are expected to exceed 1990 levels by 33% in 2010.

Growth in the transportation sector, particularly in aviation, trucking, and off-road vehicles, has outstripped significant annual efficiency gains and environmental improvements. For example, there has been a shift in consumer preference from cars to greater GHG-emitting minivans and sport utility vehicles (SUVs). In 1999, SUVs accounted for 11.6% of all new vehicles sold in Canada and about 5.5% of all vehicles on the road. Freight activity increased 32.7% between 1990 and 1999, while passenger activity increased 13.3%, which includes the substantial growth in the SUV market. Table 4.2 shows the actual and projected increase in vehicles on the road and in road traffic from 1990 to 2010.

Automobile ownership is high in Canada, largely for reasons of necessity (due to urban sprawl and long distances between city centres), but also for convenience and comfort. The 1994–1996 Canadian National Private Vehicle Use survey shows an average of 1.3 vehicles per household. The average number of vehicles per household in France, Germany, and the United Kingdom is lower. Moreover, during the same period, 45% of Canadian households owned at least one light-duty vehicle (passenger car, pickup truck, or van), and 36% owned two vehicles or more.

The policy approach to transportation GHG emissions requires the close coordination of federal, provincial, and territorial governments and includes promotion of behavioural changes, infrastructure modernization and adaptation, urban planning upgrades for efficient and integrated transport systems, and technology development (e.g., fuel-efficient vehicles, low- or non-carbon fuel systems). Canada–U.S. cooperation is also required, given the integrated North American vehicle production market and the goal of achieving harmonized new fuel efficiency standards by 2010.

Key P&Ms include:

- *Intelligent transportation systems (ITS)*: In Alberta, ITS measures such as incident management, adaptive signal control systems, and traveller information are facilitated through provincial funding. Some $4.38 million has been budgeted (Government of Alberta).

- *SkyTrain expansion*: The Province of British Columbia has committed $1.167 billion to extend Greater Vancouver's rapid transit SkyTrain line, linking Vancouver to Coquitlam and New Westminster, and purchase 60 new SkyTrain vehicles, as the result of a June 1998 agreement with Bombardier Inc. Completion of the first phase is expected in 2002 (Government of British Columbia).

- *Transit enhancement*: The cities of Calgary and Edmonton have identified transit bus renewal and light rail expansion as investment areas in their respective transportation infrastructure investment plans. This has been budgeted at $420.5 million, covering 2001–2005 (Government of Alberta).

- *Canadian Transportation Fuel Cell Alliance*: This proposal is for a five-year federal program, with additional co-funding from provinces and the private sector, to demonstrate GHG reductions, evaluate various fuel routes for fuel cell vehicles, and develop the necessary supporting framework for the refuelling infrastructure, including technical standards, codes, training, certification, and safety (Government of Canada).

Table 4.2 Growth in Canadian Transportation, 1990–2010

	1990	1995	2000	2005	2010
Light-Duty Vehicles					
Passenger Car Stock (millions)	11.1	10.9	11.4	11.9	12.2
Light-Duty Truck Stock (millions) (vans and pickup trucks)	3.5	4.5	4.8	5.4	6.2
Cars and Light-Duty Truck Travel (billion vehicle-kilometres travelled)	266	290	300	307	340
Heavy-Duty Trucks					
Heavy-Duty Truck Stock (thousands)	271	300	308	330	367
Heavy-Duty Truck Travel (billion vehicle-kilometres travelled)	14	19	21.6	23.5	26

Source: Natural Resources Canada (Analysis and Modelling Division)

- *Fuel efficiency*: The Government of Ontario is preparing best management practices to improve the fuel efficiency and the emissions performance of vehicle fleets in the public and private sectors (Government of Ontario).

Cross-Sectoral Actions: Framework and Partnership Actions

Broader actions by all Canadian sectors on mitigation and adaptation are required to address climate change. The FNBP, which includes Action Plan 2000, is designed to assist in these efforts by building partnerships with provinces, territories, and stakeholders, setting a course of action for comprehensive emission reduction strategies within and across all industrial sectors, addressing particular GHG issues related to regional situations, and leveraging more funding for GHG reduction efforts. This range of activity includes enhancing frameworks for voluntary commitments, eliminating policy barriers, and encouraging voluntary systems for trading emissions.

Voluntary Actions — Voluntary Challenge and Registry Inc. (VCR) and EcoGESte

VCR is a stand-alone, not-for-profit corporation dedicated to encouraging private and public sector organizations to voluntarily limit their net GHG emissions as a step toward meeting Canada's climate change goals. In effect, VCR and EcoGESte are registries that encourage organizations to develop and implement GHG reduction plans. Developed in late 1994, VCR became a core element of Canada's NAPCC. VCR completed its transition from a government-incubated program to a stand-alone private–public partnership in 1997, with two-thirds of its funding coming from the private sector and one-third from federal and provincial governments. Organizations from all sectors of the economy have joined the initiative, including the federal government and all provincial/territorial governments. VCR's roles and responsibilities include:

- recording and documenting participation, as well as the action plans, best practices, and achievements of registrants;
- analyzing actions and achievements, considering potential for further progress, and providing related support to registrants;
- recognizing, publicizing, and promoting registrants who are making progress toward achieving Canada's climate change objectives with the support of the VCR Technical Advisory Committee; and
- preparing progress reports and annual reports and identifying issues for consideration in the evolution of VCR.

Participation in VCR has risen steadily since the program's inception. By the end of 1998, VCR counted 874 registrants, representing over 75% of the opportunity for business and governments to reduce GHG generation, including companies and organizations from all sectors of the economy. Membership was strongest in the sectors highlighted in Table 4.3.

Membership is growing in non-automotive transportation, general manufacturing, the agriculture sector, commercial and institutional sectors, and financial services (see www.vcr-mvr.ca

Table 4.3 Sectoral Participation in VCR

Participants	Registry (%)
Government of Canada	100
Provincial Governments	100
Territorial Governments	100
Oil and Gas Pipelines	100
Petroleum Products Refining	100
Coal	100
Electricity	100
Chemical	100
Steel	100
Aluminum	100
Cement	98
Oil and Gas Producers	93
Natural Gas	80
Oil Well Drillers	71
Metal Mining	45

www.menv.gouv.qc.ca/air/changement/ecogeste.htm).

Baseline Protection Initiative (BPI)
On January 12, 2000, federal, provincial, and territorial governments officially announced the BPI under the NCCP. The BPI ensures that businesses will not be disadvantaged by future policy actions with respect to the allocation of emissions, by having baseline emission levels take into account prior business actions (early actions since 1990) on climate change that are real, measurable, and verifiable. Companies can register these early actions with VCR or EcoGESte in Quebec. Baseline protection is intended to remove disincentives to early emissions reduction actions. Through BPI, those who take steps to reduce their GHG emissions will be able to ensure that they are not disadvantaged if a future climate change policy initiative based on past emission levels is adopted. Organizations with early actions registered in the BPI registries can adjust their baseline emissions to reflect the early emissions reduction actions they have already taken.

Encouraging GHG Emissions Reductions
Efforts are under way to test the feasibility of establishing incentives to promote emissions reduction. These pilots will seek emissions reductions in strategic program areas and will focus on dollar-based incentives:

- *Domestic Emissions Trading (DET) Study*: This ongoing federal, provincial, and territorial study is looking at emissions measurement, broad versus narrow DET coverage, transition to DET, harmonization with any U.S. DET system, and permit allocation options.

- *Greenhouse Gas Emission Reduction Trading (GERT) Pilot*: The B.C. government is spearheading implementation of the national GERT Pilot to test the effectiveness of emissions trading to decrease emissions. The GERT Pilot is recognized internationally as being on the leading edge in the search for practical approaches to emissions trading. The GERT Pilot has been extended for another two years to December 31, 2001 (Governments of Saskatchewan, Nova Scotia, Alberta, and Canada).

- *Pilot Emission Reduction Trading Project (PERT)*: Established in 1996, the Pilot Emission Reduction Trading Project is an industry-led, multistakeholder environmental initiative. The federal and Ontario governments and national companies are utilizing PERT to evaluate, in part, the effects of climate change (see www.pert.org for more information).

CONCLUSION

Since the Second National Report of 1997, Canadian governments have instituted a comprehensive NCCP through the NIS and FNBP. As a component of the FNBP, it is estimated that the policies and measures announced in the Government of Canada's Action Plan 2000 will reduce GHG emissions by 65 Mt annually during the 2008–2012 commitment period. Including climate change efforts by the private sector, Canada has implemented and will continue to implement an array of substantive policies and measures designed to significantly reduce GHG emissions across all key sectors. These policies and measures encompass science, impact, and adaptation-related matters. A complete list of Canada's planned or implemented policies and measures on a sector-by-sector basis, including Action Plan 2000 measures, appears in Appendix 1, Table 1. Canada has also made important progress in areas such as increasing energy efficiency and reducing the energy intensity of GHG-emitting fuels. Emissions would have been higher without these important efforts.

REFERENCES

National Climate Change Process (NCCP)

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CHAPTER 5 Emission Projections to 2020

INTRODUCTION

Chapter 5 presents reference projections of Canada's greenhouse gas (GHG) emissions for the period 2000–2020. *Canada's Emissions Outlook: An Update (CEO99)*, released in December 1999 by the Analysis and Modelling Group (AMG) of the National Climate Change Process (NCCP), serves as the basis for the analyses of this chapter. CEO data from a previous version of this publication were similarly the basis for GHG emissions reporting in Canada's 1997 Second National Report on Climate Change. After the publication of *CEO99*, new measures and programs to reduce GHG emissions were announced, and some data revisions and changes of methodologies occurred. These updates have been reflected in a revised version of *CEO99* and are incorporated into this chapter (for simplicity, this final, revised version of *CEO99* will be referenced as the "Revised Update" in the remainder of the chapter). Where warranted, the impact of these new programs and methodologies on the projections is specifically highlighted.

The projections cover emissions from energy use, about 80% of total emissions, and non-energy sources, about 20% of the total. The estimates for the former were developed, in consultation with federal, provincial, and territorial organizations, by Natural Resources Canada (NRCan), while the emissions from non-energy sources were estimated in consultation with Environment Canada and Agriculture and Agri-Food Canada. Many policies and measures from the First National Climate Change Business Plan (FNBP) are currently in the earliest planning phases, so their likely impact cannot yet be projected with a high level of precision.[35]

To generate the most accurate scenarios (data/outputs) that can cover different time periods (2010, 2020), an important set of variables — federal and provincial energy, environment, and related policies — is held constant. For this reason, the emission projections provided in this chapter are not in the strict sense of the term a forecast. This approach means that the outlook for GHGs is predicated on the maintenance of current federal and provincial energy and related policies over the long term. The benefit of this approach is that benchmarks are established that include only the impacts of existing measures and regulations that are sufficiently advanced that we could determine their direction and implications. The projections incorporate only the impacts of those new technologies that are expected to be realized under normal economic circumstances or are the result of current federal and provincial policies. This approach to emission projections was also employed for the 1997 Second National Report.

A critical element of current policies incorporated into the projections is the effect of existing federal, provincial, and municipal energy efficiency and alternative energy initiatives, particularly those implemented through the 1995 National Action Program on Climate Change (NAPCC) and its private sector component, the Voluntary Challenge and Registry Inc. (VCR) program.[36] VCR, involving significant private sector participation, also plays an important role in these energy areas. However, since there has been no recent full-scale review of all federal, provincial, and territorial NAPCC initiatives or of more recent VCR submissions, the impact of some recent activities is not fully reflected in the projections. It should be noted that for the Second National Report, NRCan undertook an extensive review of 272 initiatives and 235 VCR submissions.

The cut-off point for inclusion in the projections is some NAPCC-related policies and measures and the full impact of the Government of Canada's Action Plan 2000 on Climate Change. Action Plan 2000, whose goals are similar to the shared goals of the broader FNBP, targets key sectors by investing $500 million over the period 2001–2006 on measures to address climate change and reduce GHG emissions. This funding is in addition to the $625 million for climate change activities announced in the Government

35 See Chapter 4 for more details on the FNBP, Action Plan 2000, the National Action Program on Climate Change, the Voluntary Challenge and Registry Inc., and the Issue Tables/Working Groups referenced in this chapter.

36 In Quebec, this program is administered by the provincial government under the name "*Programme québécois d'enregistrement des mesures volontaires sur les changements climatiques*" and is referred to as "EcoGESte."

of Canada's February 2000 budget. It is projected that full implementation of Action Plan 2000, resulting in estimated emissions reductions of 65 Mt per year during the 2008–2012 commitment period, could take Canada one-third of the way to achieving the emissions target established in the Kyoto Protocol. The impacts of Action Plan 2000, as well as the broader changes that have occurred since the publication of the Second National Report, are explained in more detail throughout this chapter.

The remainder of the chapter is organized into the following sections:

- "Projection Process" describes the assumptions, models, policy setting, and consultation processes used in developing the projections and compares these elements with those reported in the 1997 Second National Report.
- "Major Revisions to Methodologies and Assumptions" briefly describes the emissions consequences of the changes (data revision and changes in methodologies), including the impacts of initiatives that have occurred since 1997.
- "GHG Emission Projections" provides an overview of the GHG emission projections from various perspectives, including the impacts of initiatives of the NAPCC and Action Plan 2000, the size of Canada's Kyoto "gap," and emissions by different economic sectors.
- "Sensitivity Analysis" shows the sensitivity to changes in the major assumptions underlying the projections, such as changes to pricing and macroeconomic assumptions.
- "Summary and Conclusions" summarizes the major conclusions of the projections and suggests the policy implications.
- The Annex summarizes the main assumptions underlying the forecasting process and modelling relating to areas such as macroeconomic and demographic factors, energy prices, and characterization of current policy.

PROJECTION PROCESS

This section describes the process used in CEO99 to project energy demand, supply, and associated emissions. The main elements of this structure are portrayed in Figure 5.1.

The projection process began by defining the major framework assumptions — energy prices, the U.S. economy and energy market, Canadian macroeconomic performance and demographics, and the current policy stance — upon which the results are constructed. The assumptions were developed by, or through consultation with, experts and private consultants.

A modelling structure that combines econometric, end use, and process techniques was then used to project energy demand, supply, and associated emissions. The modelling structure used for the Revised Update projections is similar to the one utilized in the Second National Report, except a different model is used to project electricity supply. The new model for projecting electricity supply has the advantage of indicating a broader scope of technological impacts and can provide data on least-cost solutions.

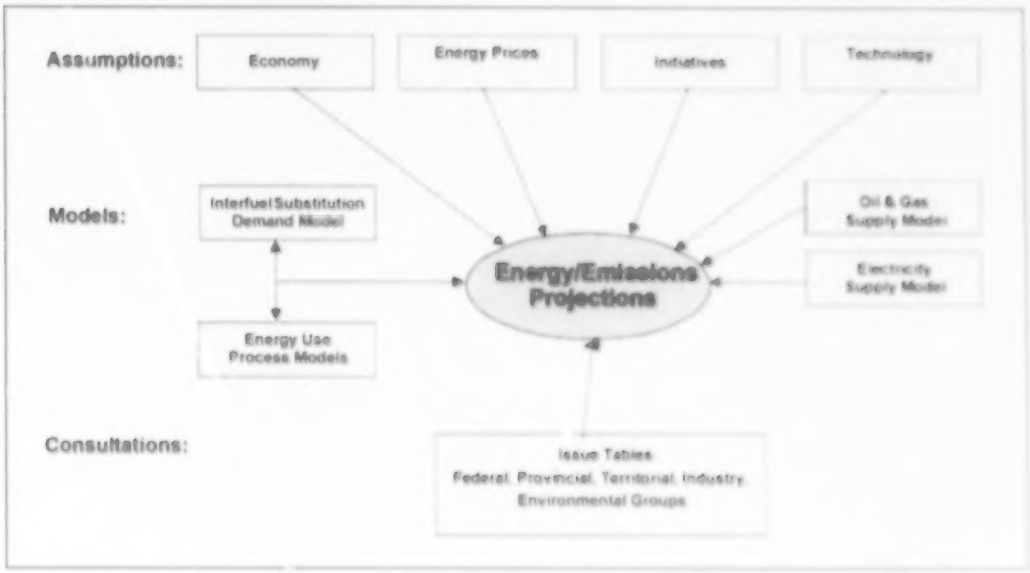
Preliminary results were shared with stakeholders for their comments and suggestions. If the comments were found to be logical and consistent with the framework assumptions, they were incorporated into the final version of the projections.

These elements are explained in more detail in the Annex.

MAJOR REVISIONS TO METHODOLOGIES AND ASSUMPTIONS

This section briefly discusses the revisions to the emissions inventory and projections by sector resulting from new information and analysis (e.g., data revisions, changes in methodologies) that have occurred since the publication of the 1997 Second National Report. These revisions and changes provide the basis for outlining the challenges facing Canada in terms of its Kyoto target and Kyoto "gap."

Figure 5.1 The Projection Process



As indicated above, the Revised Update includes the impacts of Action Plan 2000. Table 5.1 summarizes the impacts of these changes in calculating the base year 1990 inventory levels and 2010 projection estimates. The 1990 base year inventory level increases by 43 Mt over the 1997 estimates. The net impact on projections for 2010, resulting from a combination of revisions in data and methodologies (44 Mt) and changes to assumptions (57 Mt), is a projected net increase of 101 Mt beyond that reported in the 1997 Second National Report.

Impacts of Data Revisions and Changing Methodologies

Since the 1997 Second National Report, three major revisions were made to the historical estimates of Canada's GHG emissions (see Chapter 3 for details of these revisions). As a result of these revisions, the base year 1990 inventory level is adjusted upward to 607 Mt, which is 8% or 43 Mt higher than previously reported. A large portion of this increase is due to changes in methodologies for estimating nitrous oxide (N_2O) emissions from agricultural activities (29 Mt) and methane emissions from residential wood fuel (2 Mt) and from waste disposal (4 Mt). Changing methodologies have reduced the emissions from fossil fuel production by 9 Mt and from transportation by 3 Mt. The remaining sectoral changes are due to data revisions.

The impacts of these data revisions and changes to methodologies are not always proportional to the previously reported levels, nor are they linear. As can be seen in Table 5.1, some of the revisions to the projections that resulted in lower emissions in 1990 have resulted in higher emissions in 2010 (transportation and fossil fuel industry), while some that resulted in considerably higher emissions in 1990 have a small impact in 2010 (industrial sector). By 2010, the total impact of these data revisions and changes in methodologies is expected to be 44 Mt.

Impacts of Changes in Assumptions

Changes in the assumptions underlying the projections are expected to increase total GHG emissions in 2010 by 57 Mt compared with the previous report. Some of the resulting major sectoral changes are summarized below.

Electricity Generation

Emissions from electricity generation in 2010 have been revised upward by about 9 Mt. This increase in projected emissions is the result of the following counterbalancing factors:

Table 5.1 GHG Emissions: 1990 Inventory Levels and 2010 Projections

Sector	Source of Change	Emissions (Mt)	
		1990	2010
Energy	**Second National Report**	**178**	**206**
Electricity Generation	Data & Methodologies Revisions	+1	
	Changes in Assumptions		+9
Fossil Fuel Industry	Data & Methodologies Revisions	-9	+5
	Changes in Assumptions		+23
	The Revised Update	**170**	**243**
Industrial	**Second National Report**	**119**	**135**
	Data & Methodologies Revisions	+18	+10
	Changes in Assumptions		+3
	The Revised Update	**137**	**148**
Buildings	**Second National Report**	**70**	**71**
Residential & Agriculture	Data & Methodologies Revisions	+2	+2
Commercial & Public Administration	Changes in Assumptions		+4
	Data & Methodologies Revisions		
	Changes in Assumptions		+1
	The Revised Update	**72**	**78**
Transportation	**Second National Report**	**149**	**188**
	Data & Methodologies Revisions	-3	-11
	Changes in Assumptions		+17
	The Revised Update	**146**	**194**
Agriculture (Non-Energy)	**Second National Report**	**30**	**38**
	Data & Methodologies Revisions	+29	+34
	Changes in Assumptions		
	The Revised Update	**59**	**72**
Others	**Second National Report**	**19**	**31**
	Data & Methodologies Revisions	+4	+3
	Changes in Assumptions		
	The Revised Update	**23**	**34**
Total	**Second National Report**	**564**	**669**
	Data & Methodologies Revisions	+43	+44
	Changes in Assumptions		+57
	Action Plan 2000		-65
	The Revised Update	**607**	**705**

- The more robust macroeconomic assumptions, combined with revisions to the fuel mix for different industries, increased the electricity demand projections for 2010 by 45 TWh (about 7%).

- The choice of more efficient coal-fired plants, higher utilization of natural gas for new capacity additions, and replacement of retired plants reduce emissions by 14 Mt, compared with what was previously reported.

- Finally, the assumption that a nuclear power plant in Ontario will not be restored, contrary to what was assumed in the Second National Report, increases emissions by 4 Mt.

Fossil Fuel Industry

This sector is composed mainly of oil, natural gas, and coal extraction, production, and transportation (pipelines). Since the publication of the Second National Report, there have been several significant developments in the oil and gas industry. New pipelines and pipeline expansions have been approved, major oil sands developments were announced, and oil prices have fluctuated significantly. These events and several methodological changes (such as revised GHG emissions factors and new oil and gas production profiles) are projected to increase GHG emissions by 23 Mt in 2010.

Industrial Sector

The industrial sector includes all manufacturing industries, forestry, construction, and mining, but excludes the oil and gas sector.[37] Many offsetting factors resulted in 3 Mt higher emissions in 2010. The changes that have the largest impact on increasing emissions are the more robust economic assumptions for cement (1.6 Mt) and iron and steel production (1.2 Mt). The change most responsible for reducing emissions is the reduction in the use of sulphur hexafluoride (SF_6) in smelting and refining (1.5 Mt).

Residential Sector

Due to the assumptions regarding higher economic activity and a revised timetable for the updating of space heating equipment energy efficiency standards and adoption of the Model National Energy Code for Buildings by all provincial and municipal jurisdictions, the emissions in the residential sector are revised upward by 4 Mt in 2010.

Commercial Sector

This sector includes commercial and institutional buildings such as offices, retail establishments, schools, and hospitals. Many offsetting factors resulted in 1 Mt higher emissions in 2010. Factors that are expected to increase emissions in this sector include higher economic activity (2 Mt) and non-adoption of the Model National Energy Code for Buildings (1 Mt). The following factors are expected to reduce emissions: further efficiency improvements attributable to the Commercial Building Incentive and Energy Innovators Plus programs, introduced in 1998 (1 Mt), and accelerated building retrofits (1 Mt).

Transportation

Changes to assumptions about economic growth, diesel fuel demand, catalytic converter effectiveness, fuel efficiencies, and the use of alternative fuels resulted in 17 Mt more GHG emissions projected for 2010.

GHG EMISSION PROJECTIONS

Impacts of Action Plan 2000

This section briefly discusses the sectoral impacts of the Government of Canada's Action Plan 2000 on Climate Change, announced in October 2000. This plan focuses on GHG reductions and sets the stage for future reduction measures. The plan draws extensively on the results of consultations and analytical work[38] initiated by Canada's first ministers (the Prime Minister and 13 provincial and territorial leaders) to develop a process to achieve "a thorough understanding of the impacts, the costs and the benefits of the Kyoto Protocol's implementation and of the various implementation options open to Canada." Figure 5.2 outlines the rough percentage share allotted to each sector for achieving the 65 Mt per year reductions expected from Action Plan 2000 during the commitment period of 2008–2012.

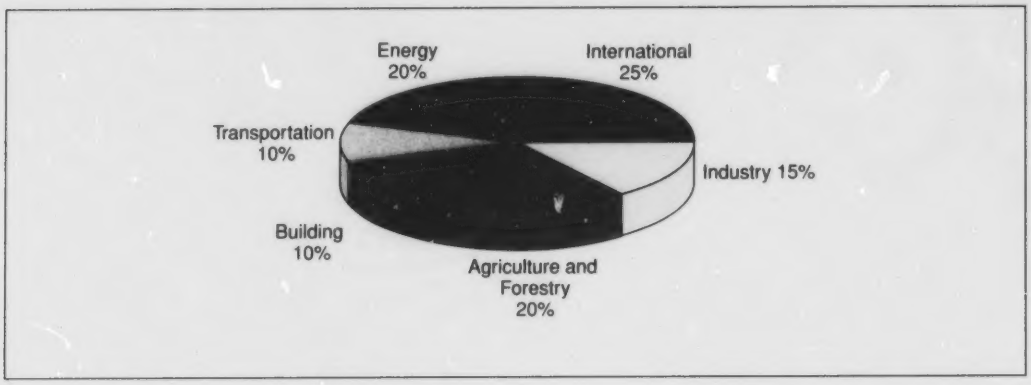
Energy

This sector comprises electricity generation and oil and gas production. Measures in Action Plan

37 Emissions from non-combustion uses of energy (feedstock, asphalt, etc.) and from fuel use in petroleum refining are included in the industrial sector. Emissions from oil and gas production in the mining sector are excluded from the industrial sector and included in the fossil fuel industries category.

38 This work has produced many measures and actions to reduce GHG emissions. About 106 "generic options" were chosen to evaluate their integrated impact. The results of this evaluation can be found in An Assessment of the Economic and Environmental Implications for Canada of the Kyoto Protocol, published by the AMG in November 2000. This report can be found on the NCCP Web site (www.nccp.ca/NCCP/pdf/AMG_finalreport_eng.pdf).

Figure 5.2 Sectoral Contributions to Action Plan 2000 Emissions Reductions



2000 include carbon dioxide (CO_2) capture and storage in geological formations, energy efficiency, emerging renewable energy, electricity sector agreements or covenants, reduction in barriers to interprovincial trade and transmission of electricity, and consumer information.

Industrial Sector
Measures announced in Action Plan 2000 include energy conservation, industry benchmarking, an industrial building incentive program, and renewable energy technologies.

Buildings
This sector includes residential, commercial, and institutional buildings. Action Plan 2000 identifies four measures: commercial retrofits, R-2000 standards for residential buildings, standards for equipment and appliances, and energy codes.

Transportation
Action Plan 2000 identifies programs in areas such as fuel efficiency, new fuels, fuel cell vehicles, freight transportation, and urban transportation.

Agriculture and Forestry
Measures announced in Action Plan 2000 include nutrient management, livestock management, soil management, afforestation, and shelterbelt planting. These measures are expected to result in more efficient application of fertilizers, increased sequestration on grasslands, and increased use of conservation tillage.

International Mechanisms
These include promotion of Clean Development Mechanism/Joint Implementation (CDM/JI) projects in other countries and technology marketing. Under the Kyoto Protocol, reductions due to these mechanisms could contribute to Canada meeting its Kyoto commitment.

Impact of NAPCC Initiatives

As mentioned in the Introduction, the Revised Update incorporates estimates of the impact of federal, provincial, and municipal initiatives, including the VCR program, resulting from the 1995 NAPCC. The Revised Update incorporates key changes and events that occurred since the last National Report. These include a revised timetable for some regulations, new federal government program activities introduced in 1998 (Innovators Plus, Energuide for Houses, Commercial Building Incentive Program, Renewable Energy Deployment Initiative), the impact of Action Plan 2000, and the commitments of magnesium producers to eliminate sulphur hexafluoride.

Table 5.2 provides estimates of NAPCC initiatives and their impact on emissions for 2000, 2010, and 2020. The first line shows the emissions level that would have been projected in the absence of the initiatives. The following panel details the emissions impact of the initiatives by sector. Among the various initiatives, those from non-energy — the nitrous oxide reduction from adipic acid and the sulphur hexafluoride elimination by magnesium producers — have a

Table 5.2 Impact of NAPCC Initiatives

	Emissions (Mt CO_2 eq.)		
	2000	2010	2020
Emissions Level, Pre-Initiatives	740	830	952
Impacts of Initiatives (Reduction)			
- End Use	12	26	61
- Electricity Generation	3	3	3
- Fossil Fuel Production	10	19	24
- Non-Energy	10	12	13
Total Impact of Initiatives	35	60	101
Emissions Level Post-Initiatives	705	770	851
Initiatives as Percentage of Pre-Initiative Level	4.8	7.2	10.6

large immediate impact. By contrast, the impact of the initiatives in fossil fuel production and the end use sectors grows appreciably over time, since these depend on capital stock turnover.

Overall, the NAPCC initiatives are estimated to reduce emissions by 35 Mt in 2000, 60 Mt in 2010, and about 100 Mt in 2020.

The remainder of this section explores several perspectives on the total GHG estimates. These perspectives include:

- the magnitude of the "gap" — the difference, in 2010, between the Kyoto target and the Revised Update;
- the distribution of the GHG projections by gas, by fuel, by sector, and by province; and
- the sensitivity of the estimate of the "gap" to changes in underlying variables, such as world oil prices and economic growth.

The Kyoto Gap

Figure 5.3 provides the overall projected trend in Canada's GHG emissions from 1990 to the end of the second decade of the new century, after including the projected impacts of Action Plan 2000. It offers an estimate of the magnitude of the Kyoto challenge, expressed as the gap between the Revised Update and Canada's target under the Protocol (6% below 1990 levels, on average, over the 2008–2012 period).[39]

As indicated, the adjusted 1990 GHG emissions level is estimated at 607 Mt CO_2 eq.; consequently, Canada's Kyoto target[40] by 2010 is adjusted to 571 Mt. The projections, incorporating NAPCC activities only, would suggest that, by 2010, Canada's GHG emissions would increase to 770 Mt (see Figure 5.3). To achieve that target under this premise, emissions in 2010 would have to be reduced by 199 Mt, or 26%. This compares to a gap of 21% reported in the Second National Report. With GHG reductions from Action Plan 2000 also incorporated into the projections, Canada's GHG emissions in 2010 are estimated to be 705 Mt. Based upon these updated projections, Canada's Kyoto gap would therefore be reduced to 134 Mt (or an 19% gap) from 199 Mt, a net difference or improvement of 65 Mt.

As indicated in Figure 5.4, all orders of government have undertaken significant climate change actions to reduce GHG emissions. Without accounting for the cumulative impacts of Action Plan 2000 and the NAPCC, Canada's GHG emissions, by 2010, would have been 830 Mt. Under this scenario, Canada would be facing a projected Kyoto gap of 259 Mt.

As noted in the Introduction of this chapter, at the time of writing, the broader impact of the FNBP policies and measures on GHG emissions reductions cannot yet be estimated. Furthermore, the potential overall contribution of sinks and sources under Kyoto Protocol articles 3.3

39 The Kyoto Protocol covers six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The aggregate target is established using the carbon dioxide equivalent of each of the GHGs. For the three synthetic GHGs — HFCs, PFCs, and SF_6 — a country can use either a 1990 or a 1995 base, whichever is most advantageous. Based on the data for those emissions, Canada will use a 1990 base.

40 The Kyoto target is specified over the average of the five years of the commitment period 2008–2012.

Figure 5.3 Revised Update: Total GHG Emissions and Kyoto Target

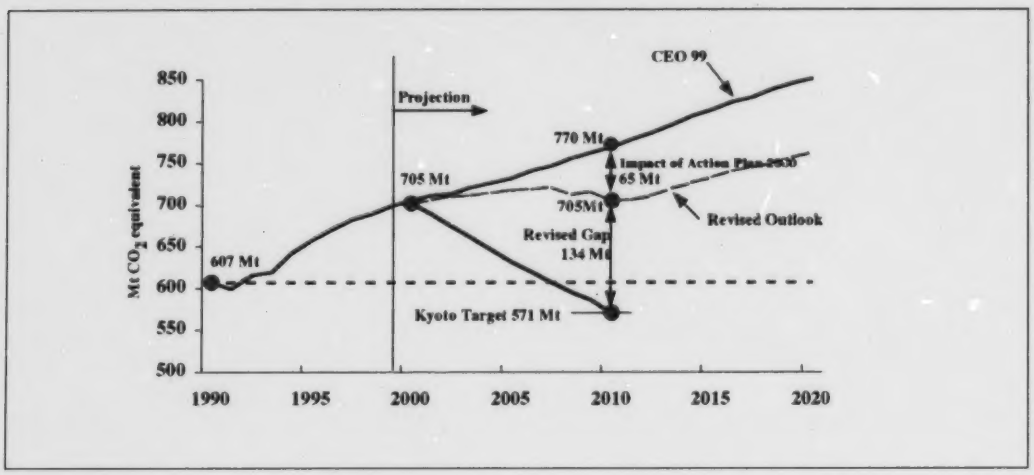


Figure 5.4 Kyoto Target: Impact of Government Plans

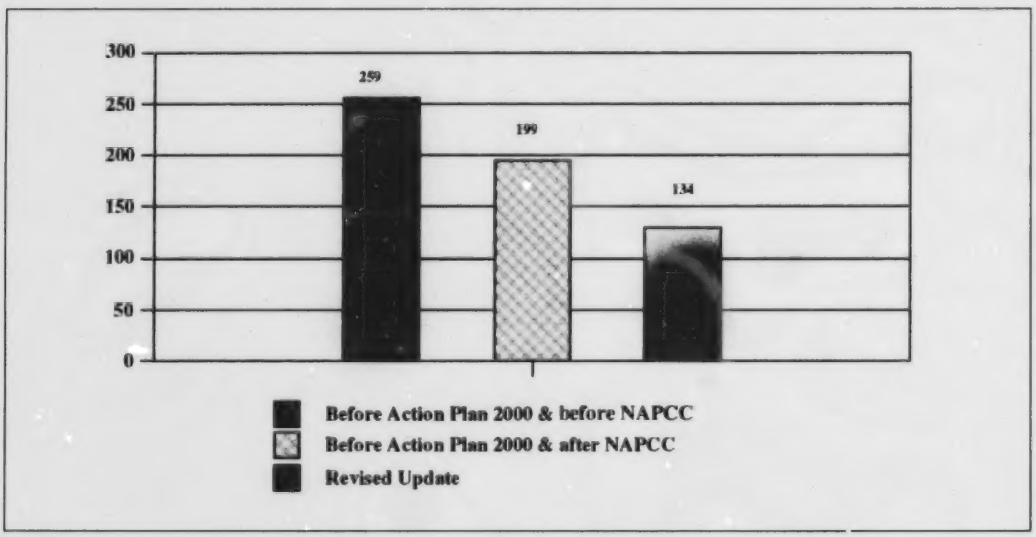


Table 5.3 GHG Emissions by Gas, 1990–2020

	Emissions (Mt CO_2 eq.)							
	1990	1995	1999	2000	2005	2010	2015	2020
Carbon Dioxide	472	501	546	548	571	599	636	666
Methane	73	88	90	90	90	92	96	99
Nitrous Oxide	53	61	54	58	60	64	64	66
Sulphur Hexafluoride	3	2	2	1	1	1	1	1
Perfluorocarbons (PFCs)	6	6	6	6	6	6	6	6
Hydrofluorocarbons (HFCs)	0	1	1	2	4	7	11	14
Total	607	659	699	705	732	770	814	851
Impacts of Action Plan 2000	-	-	-	-	-29	-65	-77	-87
Total Revised Emissions	**607**	**659**	**699**	**705**	**703**	**705**	**737**	**764**

Note: Totals may not add due to rounding.

(reforestation, afforestation, and deforestation) and 3.4 (e.g., additional forestry activities and agricultural soils) has been excluded from the calculations of the Kyoto gap. This is because it is unclear, at the time of writing, how these various activities will be defined and accounted for under Kyoto. Only the specific incremental contributions to the gap of the sinks-related Action Plan 2000 measures have been included.

Emissions by Gas

Table 5.3 provides a view of the projected long-term trends in GHG emissions by gas. By 2010, carbon dioxide emissions are expected to be 127 Mt (27%) higher than in 1990. By 2020, they are expected to be 194 Mt (41%) higher. Given the dominance of carbon dioxide in total GHG emissions, its growth accounts for about 80% of the emissions increases between 1990 and 2010.

Methane emissions generally follow the overall upward trend. Nitrous oxide emissions decline after 1995 and remain around the 1995 levels until 2020. This pattern is the result of two offsetting developments. First, DuPont installed an emission control technology in 1997 at its Maitland, Ontario, adipic acid facility that eliminates about 10 Mt CO_2 eq. of nitrous oxide emissions. Second, the use of nitrogen fertilizers in agriculture continues to increase over time.

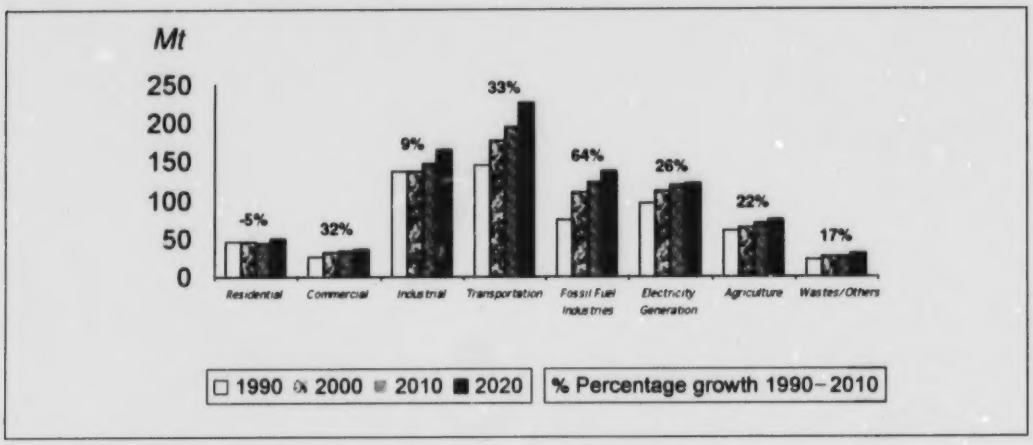
Other sources include the chlorofluorocarbon (CFC) substitutes (i.e., HFCs, PFCs, and sulphur hexafluoride). The use of sulphur hexafluoride in magnesium casting will gradually be reduced and eliminated by the year 2005. The remaining sulphur hexafluoride emissions (about 0.5 Mt) are from the other applications of this gas. HFC emissions, which did not exist in 1990, are expected to grow significantly from a small base, while PFC emissions, largely a by-product of aluminum smelting, are expected to remain constant throughout the period.

Emissions by Sector

This section explores the trends in GHG emissions by sector, with a special focus on the large contributors — transportation, industry, fossil fuel production, and electricity generation.

Figure 5.5 provides an overview of direct GHG emissions by sector, excluding the impacts of Action Plan 2000. For the fossil fuel industry, which is the largest contributor to emissions growth, emissions are expected to increase some 64% between 1990 and 2010. This increase largely reflects the growth in oil sands production and higher natural gas exports to the United States that are anticipated to occur during this period. Emissions in this sector grew rapidly from 1990 to 2000. From 2000 onward, emissions are expected to increase, but at a lower rate of growth. This trend is related to the increasing effectiveness of initiatives to constrain carbon dioxide emissions and methane leakage by the oil and gas industry, which takes place against a backdrop of significantly increased production. Canadian crude oil production is projected to increase about 24% between 2000 and 2010, then to increase 13% to 2020; exports are expected to increase about 30% over the same period, with a slight increase thereafter to 2020. Canadian crude oil consumption is projected to increase about 25% from 2000 to 2020.

Figure 5.5 GHG Emissions by Sector, 1990–2020



Natural gas production in Canada is expected to increase around 20% from 2000 to 2010 (from 168 to an estimated 200 billion cubic metres annually) and then increase to around 224 billion cubic metres annually by 2020. Annual Canadian consumption of natural gas is expected to increase from 79 billion cubic metres in 2000 to 94 billion cubic metres in 2010 and 117 billion cubic metres in 2020.

The projected emissions growth in the transportation sector — some 33% between 1990 and 2010 — is closely related to the growth in travel and freight services, but the off-road component related to oil, natural gas, and coal mining activity also plays a role. The increase in emissions from the industrial sector is also significant, but the pace is somewhat slower, owing, primarily, to greater energy efficiency improvements and reductions in certain process emissions (e.g., nitrous oxide from adipic acid and sulphur hexafluoride from magnesium smelting). The residential sector generates a slight decrease, while the commercial sector experiences about a 32% increase in emissions. The slight decrease in residential emissions is closely linked to the impact of energy efficiency regulations on buildings, heating systems, and other energy-using equipment.

For electricity generation, emissions in the Revised Update are projected to grow rapidly from 1990 to 2010. After 2010, however, growth declines as existing coal-fired plants, reaching the end of their service life, are retired and are projected to be replaced by natural gas or highly efficient coal-fired plants.

Emissions related to agriculture (non-energy) are expected to increase about 22% between 1990 and 2010. Emissions from waste and CFC substitutes are expected to increase by some 17%. The major driver of this growth is the increasing use of HFC substitutes for CFCs.

Emissions by Province

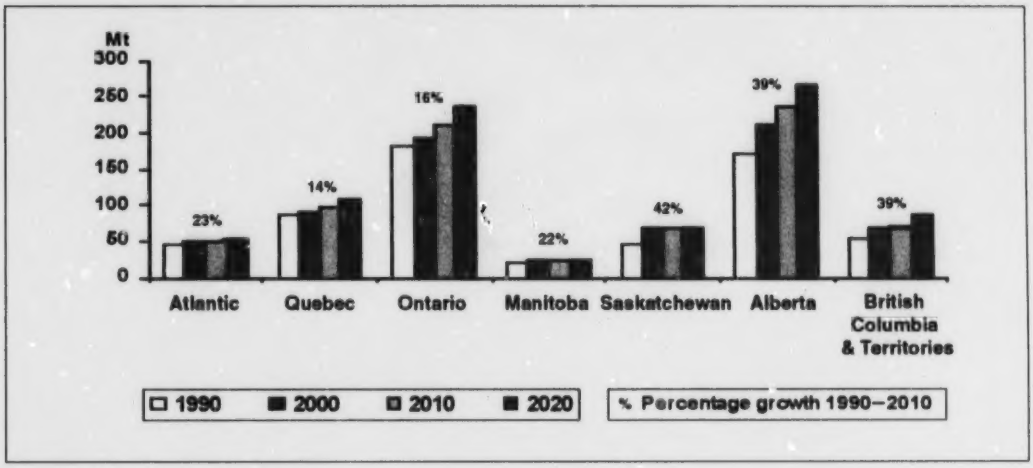
Figure 5.6 portrays long-term emissions growth on a provincial and territorial basis. The pattern of emissions growth varies across provinces, largely reflecting the distribution of energy reserves and production, manufacturing activities, and population densities.

The highlights of emissions growth in the provinces and territories are as follows:

- Between 1990 and 2010, the provinces of British Columbia,[41] Alberta, and, Saskatchewan are expected to experience the largest increases. Emissions for Alberta, British Columbia, and Saskatchewan are expected to increase by some 39%. By

41 British Columbia includes the emissions projections for the territories.

Figure 5.6 GHG Emissions by Province, 1990–2020



contrast, emissions in Quebec are expected to increase only 14%.

- Between 1990 and 2010, emissions in the Atlantic region are expected to increase 23%. Newfoundland experiences the largest increase, due to increased economic activity resulting from projects such as Hibernia and Terra Nova.

Sensitivity Analysis

The reference case projections are only one among many possible views of the future. Changes in any of the key assumptions will result in a different outcome for energy demand and supply and GHG emissions. This section reviews the implications, for the Kyoto gap, of changing world oil prices, increasing and decreasing economic growth, and greater declines in the rate of carbon intensity (see Figure 5.7).

Lower World Oil Prices

Under the lower price scenario, the world oil price is assumed to fall and remain $5 (US$ 2000) per barrel (bbl) below the reference projection over the entire forecast horizon.

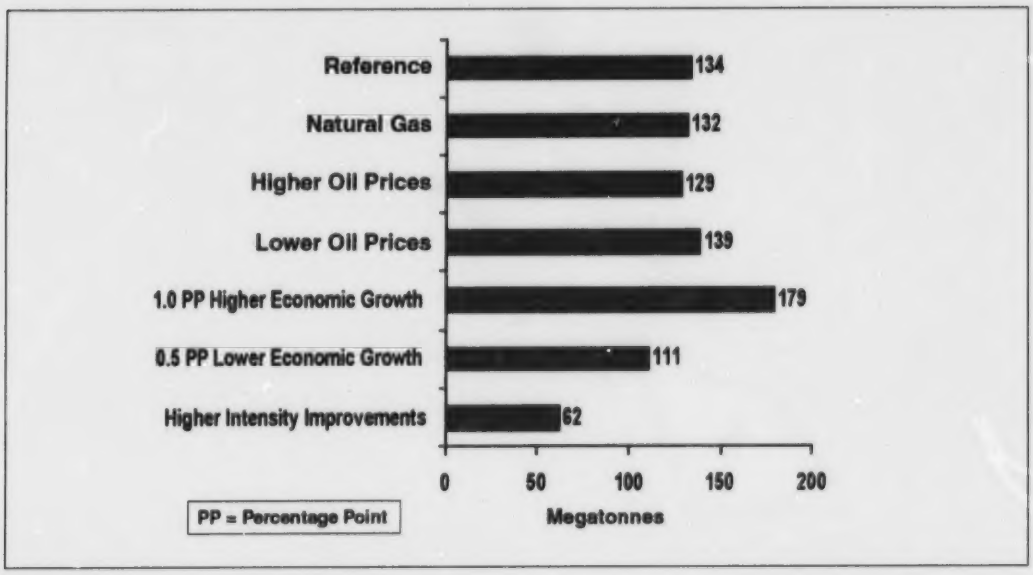
A sustained lower world oil price reduces crude oil production and increases the demand for petroleum products. These demand and supply changes have opposite effects on GHG emissions.

The higher energy use leads to a 20 Mt increase in GHG emissions by 2010. On the supply side, however, a drop in oil prices to US$17/bbl negatively impacts project economics and industry cash flow and, consequently, oil production. As a result, emissions from the upstream oil and gas sector would decline by 15 Mt. The net outcome of lower oil prices is, therefore, a 5 Mt increase in the gap.

Higher World Oil Prices

In this case, world oil prices are assumed to rise to about US$27 (a price similar to present world oil prices) and remain at US$5/bbl above the reference level throughout the forecast period. As in the case of lower prices, the price change has opposite effects on energy demand and supply. Petroleum product demand is reduced by the higher prices, while crude oil production is positively affected. Lower energy use reduces GHG emissions by 20 Mt in 2010 relative to reference case levels. Higher oil prices are expected to advance the start-up of most synthetic oil sands projects and increase bitumen production and conventional production. As a result, emissions are expected to increase by 15 Mt. The net effect of higher oil prices is, therefore, a 5 Mt decrease in the gap.

Figure 5.7 Sensitivity Analysis: Projected Changes in the "Gap"



Higher Natural Gas Prices

This simulation assesses the impact of higher natural gas prices on the gap. Canadian natural gas prices are assumed to be 50% above the reference case. This scenario also assumes that the production and processing costs of natural gas increase by 50%.

Higher natural gas prices result in lower natural gas consumption and higher oil and coal consumption. The impact on natural gas production is assumed to be negligible, as the surplus will be exported to the United States. The total impact on GHG emissions by 2010 is expected to be very small. Lower consumption of natural gas will reduce emissions by 13 Mt, while higher consumption of oil and coal will increase emissions by 8 Mt and 3 Mt, respectively.

Lower Economic Growth

For the lower economic growth case, a generalized growth rate of 0.5 percentage points below the reference is assumed.[42] As a consequence, the economy would be approximately 5.5% smaller by 2010. This represents a pessimistic view of the long-term prospects for economic growth, despite the uncertainty of 2001, since gross domestic product (GDP) grew 4.5% in 1999 and is projected to have grown more than that in 2000.

Energy demand would be expected to be about 4% lower in 2010. The lower energy demand translates into a 23 Mt reduction in GHG emissions by 2010 relative to reference case levels.

Higher Economic Growth

In this scenario, GDP is assumed to grow 3.3%, on average, per year over the 2000–2010 period, instead of the 2.3% of the reference case forecast. The improved performance results in economic output that is approximately 11.5% higher in 2010 relative to reference case levels. As a result of higher economic growth, emissions in 2010 are 45 Mt higher, an increase of approximately 35% in the gap relative to reference case levels.

42 In order to accommodate this lower growth, labour productivity is assumed to grow 0.5% less per year. This is reflected in a corresponding decrease in real personal disposable income because of a decline in the real wage rate to compensate for lower productivity gains. A significantly lower economic growth assumption (e.g., 1% less per year) would necessitate changes to assumptions concerning demographic trends, labour markets, structural shifts in economic production, etc.

Increased Carbon Intensity Improvements

Carbon intensity, defined as GHG emissions divided by GDP, is a key aspect of emissions trends. In the reference case, the carbon intensity decreases at an annual rate of 2.2% between 2000 and 2010. Increasing the carbon intensity improvements by 50% across the economy would reduce the gap to 62 Mt, or roughly halfway to the Kyoto target, by 2010. Doubling the carbon intensity improvements would be enough to achieve the Kyoto target.

SUMMARY AND CONCLUSIONS

This chapter has incorporated the Revised Update (based on CEO99) of Canada's GHG emissions and adjusted estimates published in the 1997 Second National Report. The Revised Update provides adjustments for Canada's 1990 base year and projections for 2010 based upon the impact of the most recent activities and events, changes to assumptions, and the application of new methodologies:

- Canada's estimated 1990 GHG emissions levels are revised to 607 Mt, an increase of 43 Mt, and the resulting upward adjustment to Canada's Kyoto target is adjusted to 571 Mt. (This represents a reduction of 6% from 1990 levels.)

- Updated projections indicate that Canada's GHG emissions could be 101 Mt higher in 2010, compared with projections in the Second National Report. Prior to Action Plan 2000, the projected Kyoto gap would have been 199 Mt (about 60 Mt more than reported in the Second National Report). However, with the Government of Canada's Action Plan 2000 and its planned annual GHG emissions reductions target of 65 MT, Canada's Kyoto gap for 2010 is projected to be 134 Mt, or 19%.

The chapter has also examined the growth in emissions from several perspectives. The main conclusion is that achieving the Kyoto target represents a significant challenge. A 19% reduction in emissions implies a commensurate reduction in fossil fuel use. The gap is roughly equivalent to all of the emissions in 2010 from the industrial sector. Furthermore, the analysis of the proximate causes of GHG emissions suggests that to accomplish this task by domestic action alone would require a large reduction in carbon intensity.

The results also indicate fairly pronounced regional and sectoral variations in emissions growth. From the provincial perspective, results indicate that there would be a small increase in Quebec emissions between 1990 and 2010. By contrast, emissions in Alberta, British Columbia, and Saskatchewan are expected to increase 40%. By sector, fossil fuel production and transportation exhibit rates of growth considerably in excess of those of the industrial and electricity generation sectors.

In meeting these challenges, Canadians have undertaken a wide array of cross-cutting policies, measures, and activities that will have a substantial impact in helping Canada meet its GHG reduction goals. Important areas include full implementation of Action Plan 2000 and FNBP measures; the potential for international action on carbon dioxide reduction and other global efforts in areas such as sinks and technology transfer; future federal and provincial business planning exercises to adopt new policies and measures; improvements and investments in technology; and ongoing improvements in energy efficiency, energy intensity, fossil fuel production, and renewable and alternative energies.

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ANNEX: PROJECTION PROCESS

This annex explains in detail major elements underlying the forecasting process used by NRCan in developing the current projections.

Major Assumptions

This section summarizes the major assumptions — macroeconomic and demographic factors, energy prices, and the characterization of current policy — that frame the projections. It also compares these assumptions with those reported in the Second National Report.

Macroeconomic and Demographic Assumptions

The energy and emissions projections presented in the Second National Report were predicated on expected economic conditions from the perspective of late 1994. Since that time, many events, such as the Asian economic crisis, stronger economic growth in the United States, and better than anticipated fiscal conditions, have altered this economic growth profile significantly over the short and medium terms.[43] A comparison of key macroeconomic variables for the Second National Report and the Revised Update is provided below.

As highlighted in Table 5.A.1, the economic projections underlying the Revised Update are, over the medium term, more optimistic than those assumed in the Second National Report. The Revised Update forecast is based upon the more robust growth in the United States through to 2000. Given the strong trade links between the two countries, the better U.S. economic performance translates into higher Canadian growth over the period to 2000 in the Revised Update (2.9% annually versus 2.2% in the Second National Report). It is noteworthy that in the Revised Update, the improved short-term economic performance is more evenly spread between industry and services relative to the Second National Report. The revised assumption of a higher economic growth rate in services stems from the more relaxed fiscal situation, which led to greater spending on health and education (which collectively account for one-half of the service sector). In the Revised Update, the industrial sector is, by contrast, relatively

43 A more detailed explanation of the method revisions can be found in Canada's Greenhouse Gas Inventory 1990–1999 (Environment Canada, 2001).

Table 5.A.1 Macroeconomic and Demographic Assumptions

	Average Annual Growth Rates (%)			
	1995/2000		2000/2010	
	2NR[a]	Update	2NR	Update
U.S. GDP	2.3	2.8	2.0	2.2
Canada GDP[b]	2.2	2.9	2.2	2.3
Industry	3.1	2.8	2.0	2.0
Services	1.7	2.8	2.3	2.3
	2000		2010	
	2NR	Update	2NR	Update
Population (millions)	31.0	31.2	33.8	34.0
Households (millions)	11.2	12.0	12.7	13.8
Light Vehicles (millions)	16.2	16.3	18.4	19.3
Disposable Income per Household ($1995)	51 506	49 620	54 779	55 194

(a) Second National Report.

(b) Total GDP includes other industries, such as agriculture, transportation, and utilities, included in industries and services.

smaller in 2000, owing to a slightly lower rate of economic growth.

Table 5.A.1 also shows that while the short-term performance of the Canadian economy has changed in the Revised Update, the long-term growth pattern (i.e., from 2000 to 2010) is much the same. This assumption reflects the view that long-term growth is largely determined by future employment and productivity trends. At the time of formulating the framework assumptions, there was no strong consensus that these trends have been altered based on the evidence from the previous few years.

Finally, although the economic outlook used for this projection features higher GDP growth, real disposable income per household to 2000 is lower than in the Second National Report. This is partly explained through a change by Statistics Canada in its definition of households, with the result that the number of households is now greater both historically and in the projection. Based on the old household definition, real disposable income per household would be roughly 3% higher by 2000 in the Revised Update relative to the Second National Report. The initial decline in real disposable income per household and its subsequent sluggish recovery have important implications for the capacity of households to purchase new, more energy-efficient durable goods and housing.

Canada's population has also been revised upward. Canada's population is expected to grow about 0.9% per year, reaching 34.0 million in 2010. More than 60% of this increase is related to immigration. The number of households, an important determinant of energy consumption, is expected to grow faster than the population (1.2% per year), reflecting complex demographic changes related to the aging of the population. The stock of light vehicles (passenger cars, vans, light-duty trucks) increases to almost 19.3 million vehicles by 2010.

Energy Prices

The Revised Update has retained the energy price assumptions used in the Second National Report. The Revised Update, like its predecessor, is projected based on relatively low international crude prices, averaging just above $22/bbl (US$ 2000) (Table 5.A.2). This long-term price assumption is based on two factors: first, the recent national and international projected average oil price is $18/bbl in 2010 and $23/bbl in 2020. The Revised Update energy price assumption is somewhere within this forecast range. Second, world oil prices exceeding $22/bbl are due to the decision by the Organization of Petroleum Exporting Countries (OPEC) to adjust oil quotas and restoration of the strength of Asian economies.

Table 5.A.2 Energy Pricing Assumptions[a]

	2000	2010	2020
Crude Oil (US$/bbl) — West Texas Intermediate at Cushing	22.3	22.3	22.3
Natural Gas (US$/mcf) — at Henry Hub	2.12	2.3	2.3
Electricity (Cdn cents/kWh) – Residential Sector			
Ontario	9.7	8.5	9.0
Canada	8.2	9.0	8.2
Coal (Cdn$/tonne)			
Alberta (Domestic Production)	10	55	10
Ontario (Imported Coal)	55	10	55

(a) All values are in $US 2000.

Long-term natural gas price assumptions in the Revised Update are the same as in the Second National Report, which were based on only a modest price growth to $2.30 per thousand cubic feet (mcf) in 2010 and remaining at this level until 2020. Increased competition, the greater use of storage capacity, technological advances, etc. are expected to keep the natural gas price at about this level.

Electricity prices are the same as in CEO 1997 and will continue to be determined at the provincial level. Coal prices are also assumed to remain at the same level, in constant dollars, over the projected period.

Models

Demand

For energy demand, primary reliance is placed on the Interfuel Substitution and Demand model, which is a highly disaggregated econometric model covering all major fuel types and four end use sectors (residential, commercial, industrial, and transportation), specified for each of Canada's 10 provinces and 3 territories. Each of the direct energy-consuming sectors is, in turn, further disaggregated. The industrial sector, for example, is divided into 10 industries, whereas transportation separately identifies automobiles, light- and heavy-duty trucks, and the air, rail, and marine subsectors.

Econometric models are extremely powerful in addressing the behavioural aspects of energy demand. They are less successful, however, in reflecting the technological and regulatory reality underlying energy consumption. To capture both aspects, the econometric projections are calibrated, using the same assumptions, with the results of end use models maintained by NRCan. These end use models are particularly useful in estimating the effects of policy initiatives.

Electricity Generation

To project electricity generation, NRCan used the services of a consultant, *Groupe d'Etudes et de Recherches en Analyse des Décisions*. Given the projection of electricity demand, the consultant used the electricity submodel of MARKet ALlocation (MARKAL) models to project the generation of electricity by fuel types. MARKAL is a mathematical programming optimization model. This model contains information — capacity, service life, unit cost, etc. — on each existing and potential generating facility in Canada. New capacity is added, on a least-cost basis, to satisfy demand, although the generating plans of the utilities are also taken into account. Non-utility generation and co-generation are considered as potential sources.

Oil, Gas, and Coal Supply

Crude oil, natural gas, and coal supply are projected using a more eclectic modelling structure. First, major oil and natural gas projects are considered, based on their economics and industry announcements. Conventional oil and gas supply is then determined by relating exploration and development costs and the industry's reinvestment behaviour to its cash flow position. Coal supply projections are developed from projected industry requirements. In all three cases, export levels are established by an in-depth examination of domestic and foreign assessments of potential.

Greenhouse Gas Emissions

For the most part, calculation of GHG emissions related to fossil fuel consumption is straightforward. Emission factors for each fuel type have been developed by NRCan and Environment Canada based on internationally accepted conventions. For some sources, however, such as fugitive methane emissions from oil and gas production and nitrous oxide emissions from industrial processes, specific assumptions are made, based on studies of technological potential and the future trend in emissions per unit of output.

Consultations

CEO99, which is the basis for the Revised Update, was facilitated by extensive consultations with the Issue Tables/Working Groups, comprising experts from federal, provincial, and territorial governments, industry associations, and a wide range of stakeholders. The consultations on this chapter ranged from informal discussions on the framework economic assumptions to an extensive review of the initial results. Subsequent consultations were held with all provincial energy departments, regulatory bodies, industry organizations representing oil and gas producers, natural gas distributors, electricity generators, major industrial energy users and automotive manufacturers, and environmental groups. These consultations do not imply full endorsement of the Revised Update by any of the organizations or groups involved. We believe, however, that this projection reflects a broad consensus concerning the validity (or acceptability) of the results.

CHAPTER 6 Vulnerability Assessment, Climate Change Impacts, and Adaptation Measures

INTRODUCTION: IMPACTS OF CLIMATE CHANGE IN CANADA

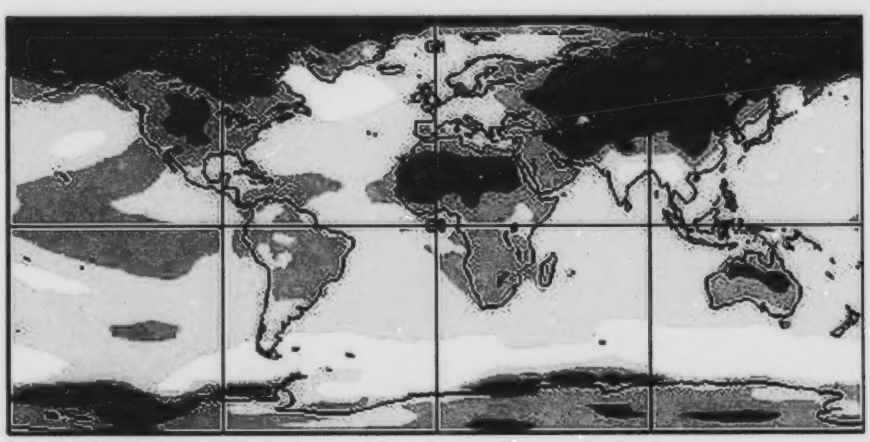
Although climate change will have consequences all over the world, not all regions will be affected equally, nor are all regions equally vulnerable to those impacts. Canada, for example, is a northern country and as such is expected to experience faster warming due to climate change than countries farther south (Figure 6.1). Moreover, while climate changes and impacts in Canada will mirror global ones, significant regional variations are anticipated due to the large size of the country, its diverse landscape, and its ocean boundaries.

Temperature changes are projected to be greatest in the north. The central area of the country, including the Prairie provinces, Ontario, and Quebec, is likely to experience more frequent and severe heat conditions. Low-lying coastal areas face risks associated with a rise in sea level, including increased flooding and coastal erosion, particularly on the Atlantic coast. The frequency and severity of extreme events could increase as a result of climate change, affecting many parts of the country. Ice-rich sediments and permafrost, for which climate is the fundamental environmental factor, are likely to begin to thaw. Thawing in these areas would greatly reduce ground strength, which may induce landslides, increase sediment contribution to rivers, and reduce or eliminate the ability of earth materials to support buildings and transportation facilities.

The effects of climate change are already being experienced in the western Canadian Arctic. This region has warmed by about 1.5°C over the past 40 years, while the central Arctic has warmed by about 0.5°C. Effects include the following:

- changes in the decreased extent and thickness of Arctic sea ice, permafrost thawing, coastal erosion, and altered distribution and abundance of some animal species;
- more open water in winter and spring, making hunting more hazardous;
- meeting of permanent snowpacks in Yukon for the first time in thousands of years; and

Figure 6.1 Annual Mean Temperature Change: 2040–2060 Minus 1970–1990



Temperature Change, °C

-0000 1 000 2 000 3 000 5 000

Canadian Centre for Climate Modelling and Analysis
Meteorological Service of Canada

- the appearance of southern species such as Pacific salmon and robins in the Arctic for the first time in memory, as cited by traditional knowledge research.

VULNERABILITY ASSESSMENT AND ADAPTATION

Vulnerability can be defined as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001). An assessment of vulnerability and adaptive capacity is a means of prioritizing and directing action where it is needed most urgently by determining which regional areas and natural or human systems are most at risk.

Adaptation refers to the adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. Adaptations vary according to the system in which they occur, who undertakes them, the climatic stimuli that prompt them, and their timing, functions, forms, and effects. They depend greatly on the adaptive capacity of an affected system, region, or community to cope with the impacts and risks of climate change. The adaptive capacity of human systems depends on such factors as wealth, technology, education, information, skills, infrastructure, access to resources, and management capabilities.

Over the last few years, a consensus has been building in Canada that the climate is changing and that measures will need to be taken to adapt to these changes. Increasingly, provincial, regional, and municipal governments as well as non-governmental organizations (NGOs) are working with the Government of Canada to include climate change as part of their long-term planning processes.

Adaptation to climate change has the potential to substantially reduce many of the adverse impacts of climate change and enhance the beneficial impacts, though not without cost or residual damages. The estimated environmental, economic, and social costs associated with the impacts of and adaptation to the current climate in Canada (including, for example, over a billion dollars annually in the water sector alone) are large, and projected changes in climate are expected to increase those costs.

The capacity to adapt climate conditions has historically been strong in such sectors as energy, transportation, and recreation and tourism, but the rate of projected warming and the prospects of future climate surprises would present serious challenges to that capacity. In most cases, the impacts on a system are dependent on both the rate and magnitude of changes in the climate and on potential lags in system responses. Adaptation is possible but would require changes in land, water, and resource management and urban planning practices (see specific examples below). In the case of natural systems, such changes would have implications for harvesting agreements, parks, private sector investments, and binational arrangements for water and energy.

Canada Country Study

In 1998, Canada completed the Canada Country Study (CCS): Climate Change Impacts and Adaptation. The CCS was a national assessment of the potential impacts of climate change and variability, including consideration of existing and potential adaptive responses. In presenting this national perspective, the CCS focused on reviewing existing scientific and technical literature that identified our understanding of impacts and adaptation options from regional and national perspectives.

The assessment involved researchers and reviewers from government, universities, and the private sector, and much of the recent research included in the study used Intergovernmental Panel on Climate Change (IPCC) impact assessment technical guidelines.

The CCS was published in eight volumes: six regional volumes (Arctic, Atlantic, Ontario, Pacific and Yukon, Prairies, and Quebec); a national sectoral volume consisting of 12 papers (agriculture, built environment, energy, fisheries,

forestry, human health, insurance, recreation and tourism, transportation, unmanaged ecosystems, water resources, and wetlands); and a cross-cutting issues volume consisting of eight papers (changing landscapes, costs, domestic trade and commerce, extra-territorial issues, extreme events, integrated air issues, sustainability, and two economies). The results were also summarized in seven plain-language documents, one for each region and one at the national level. In addition, a national Summary for Policy Makers was published. The results have been made widely available to policy makers and stakeholders across Canada and are quoted in the background documents to Canada's National Implementation Strategy on Climate Change (NIS).

The result of this initial work was information on the vulnerability of Canada's economic sectors, social well-being, and ecological systems to projected changes in climate. Highlights of the assessment are presented below:

- Canada's response to projected climate change impacts will be significantly complicated by the consequences for Canada arising from impacts projected for the international community, particularly Canada's trading partners.

- As Canada's prosperity and well-being are strongly linked to the well-being of its natural ecosystems and water resources, the responses of these entities to projected climate change will be critical in determining the environmental, economic, and social costs and benefits of climate change for Canada.

- The location, structure, and functioning of terrestrial and aquatic ecosystems would be altered as a result of expected changes in relative season length; species distribution, population, and habitat; and competition between species. Moreover, their capacity to adapt will be tested by the fast, possibly irregular, rate of warming.

- All socio-economic sectors would be impacted through additional stresses on physical and social infrastructure, ranging from altered building and construction practices to adjustments in health care to changes in subsistence lifestyles with their reliance on local knowledge.

- Harvest levels in the agriculture, forestry, and fisheries sectors are sensitive to climate change. Sustaining viable production levels will depend on the capacity of these sectors to cope with the projected rate of warming and increased climate variability, as well as on their ability to counter projected decreases in water availability and increased risks from competition, disease, and other disturbances (e.g., fire).

- Considering Canada's vulnerabilities to extreme weather and climate events, projected changes in their occurrence and severity would have serious ramifications for the security and integrity of our natural resources, social systems, and infrastructure, with subsequent implications for the insurance industry and supporting public sectors.

- In some cases, projected climate change may have positive impacts (e.g., a longer growing season and lower heating demands), which could provide adaptive opportunities or alleviate the pressures caused by other stresses (e.g., population changes, other air issues, land use alterations).

- An increased emphasis in climate impacts and adaptation research on integrated assessments, on linking with sustainable development research, and on involving stakeholders directly in related research is essential for addressing gaps in our current understanding of our vulnerabilities and adaptation options/strategies.

The CCS further noted that estimating the magnitude of impacts and costs associated with climate change remains difficult. Many factors contribute to the uncertainty associated with identifying the magnitude and costs of anticipated impacts. These include the expected future climate and socio-economic conditions, direct and indirect feedback from individual sectors and regions in Canada, global greenhouse gas (GHG) emissions, and the effect of adopted adaptation measures and how these will vary temporally and spatially within Canada.

On a national scale, Canada's high level of infrastructure, human systems, and national wealth reduce our vulnerability to the negative impacts of climate variability and change relative to other countries. On a smaller scale, however, there are regions and sectors that may be highly vulnerable to change (e.g., those in which socio-economic sustainability depends on climate-sensitive resources). Furthermore, major portions of Canada's economy are still largely natural resource–driven to a significant extent. Where some of these natural resources are at risk, steps to assess and reduce the risk need to be taken.

Natural systems identified as being at risk in Canada include glaciers, boreal forest, polar and alpine ecosystems, prairie wetlands, cold-water ecosystems, and remnant native grasslands. Other systems include marine and freshwater fisheries, coastal zones, and the Great Lakes. Human systems can also be vulnerable to climate variability and change, including water resources, agriculture, fisheries, energy, human health, and community infrastructure.

IMPACTS AND ADAPTATION RESEARCH INITIATIVES

In 1998, recognizing the need for action on climate change, the Government of Canada established the Climate Change Action Fund (CCAF), a three-year, $150 million funding program to encourage action on climate change. Among its goals was to undertake research to better determine the impacts of climate change on Canada and contribute to the development of adaptation actions.

Between 1998 and 2001, the impacts and adaptation component of the CCAF funded 76 projects investigating potential impacts and adaptation options within several natural and human systems. Workshops were also organized to facilitate discussion among experts on regional and sectoral priorities. The projects funded cover several economic and social sectors, including agriculture, forestry, human health, fisheries, water resources, coastal zones, terrestrial ecosystems, infrastructure, recreation and tourism, communities, and issues that cross sectoral and geographic boundaries. Principal investigators include scientists affiliated with the federal government, universities, the private sector, and NGOs. Projects also span the country, with research occurring in each province and territory. Results of these studies will be released during 2001 and 2002.

The CCAF requires that projects lever financial and in-kind support from other partners to approximately 50% of the total project budget. As a result of this requirement, the program has been able to achieve higher levels of productivity and build research capacity in the areas of climate change impacts and adaptation than would otherwise have been possible.

In addition to these research projects, the CCAF has produced and contributed to several outreach products specifically addressing the impacts of climate change in Canada, including production of a series of posters on the regional impacts of climate change aimed at high school students and the general public. Another project, Sensitivities to Climate Change in Canada, entails a series of maps indicating the landscapes and natural resources most sensitive to climate change.

In 2000, Canada released the NIS. This strategy takes a phased, risk management approach to the issue. It supports the need for research to reduce the uncertainties associated with the magnitude, timing, and consequences of impacts and the need to take timely and progressive action to adapt. A number of Canadian jurisdictions — the federal government and several provinces — have also released their own action plans, which support action on adaptation.

The First National Climate Change Business Plan, which describes actions to be taken in the first three years of the NIS, details four measures dealing with impacts and adaptation:

- Facilitate greater access to research results by decision makers and help incorporate their needs in setting priorities for research. To do this, the Government of Canada is leading the development of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN). This network, being developed in partnership with provincial and territorial governments, universities, and other stakeholders, will consist of six regional and seven sectoral nodes. The nodes will provide

a forum for researchers, stakeholders, and decision makers to share information and coordinate activities. The network will also be used to facilitate future national impacts and adaptation assessments.

- Expand the capacity within the impacts and adaptation research community.

- Conduct research to better determine Canada's vulnerability and contribute to the development of adaptation strategies in sectors and regions of Canada where impacts are being felt now.

- Embark on the development of a national framework for adaptation. This framework will identify the goals for adaptation, priority sectors for action, factors that need to be addressed in adaptation strategy development, and mechanisms that exist or will be needed for adaptation strategy development. As with mitigation, adaptation would likely take place in phases, depending on current vulnerability and the capacity to adapt. Where possible, the framework would provide generic guidance on the approach to phasing in adaptation strategy development and critical points to be considered (e.g., when and where a coping range is exceeded).

The Program of Energy Research and Development (PERD) is a federal energy science and technology program that designs and funds work done interdepartmentally by 12 federal departments and agencies. One of the priority areas for research is the impacts of climate change on the energy sector. Projects funded to date under this priority area include, for example, the impacts of changing sea ice and wave regimes on offshore coastal infrastructure; how impacts on water resources will affect hydroelectric and power production; the impacts of fire and pests on biomass production; and the impacts of permafrost degradation and terrain stability on pipeline and related infrastructure.

The Natural Sciences and Engineering Research Council of Canada (NSERC) is the national instrument for making strategic investments in Canada's capability in science and technology. NSERC supports basic university research through research grants and project research through partnerships of universities with industry, as well as the advanced training of highly qualified people in both areas. While NSERC does not allocate support on an issue basis, it has funded several research projects on the impacts of climate change over the last few years.

The Social Sciences and Humanities Research Council (SSHRC) is Canada's federal funding agency for university-based research and graduate training in the social sciences and humanities. SSHRC has also funded research projects on the impacts of climate change on social systems in Canada.

Several provinces and territories have also identified impacts and adaptation research as a priority within departmental programs. For example, the Government of British Columbia is pursuing research on adaptation in the fisheries sector; the Government of Saskatchewan is pursuing research on impacts and adaptation strategies for biodiversity, the forestry sector, and northern regions; and the governments of Alberta, Saskatchewan, Manitoba, and British Columbia have collaborated with the federal government to establish regional networking nodes of C-CIARN. Other nodes are expected in collaboration with the governments of Ontario, the Northwest Territories, Yukon, Nunavut, and Quebec.

SECTORAL IMPLICATIONS OF CLIMATE CHANGE IN CANADA

As stated above, the natural systems identified as being at risk in Canada include glaciers, boreal forest, polar and alpine ecosystems, prairie wetlands, cold-water ecosystems, and remnant native grasslands. Other systems include marine and freshwater fisheries, coastal zones, and the Great Lakes. Human systems can also be vulnerable to climate variability and change, including water resource management, agriculture, fisheries, energy, human health, and physical infrastructure.

Water Resources

Canadian water resources and the people and ecosystems dependent on them are becoming more vulnerable to climate variability, extremes, and changes. Although the adaptive capacity of Canadian systems is generally high and

vulnerability low, social, economic, and demographic trends suggest an increase in their vulnerabilities. For example, the knowledge and quality of the databases required for the sustainable management of water resources are decreasing as a result of reductions in monitoring, technical support, and related scientific research. In addition, water infrastructure is aging, and designs are based on past climatic conditions.

The greatest vulnerabilities lie in unmanaged water systems and systems that are currently stressed or unsustainably managed:

- *Unmanaged systems*: There are few or no structures in place to buffer the effects of hydrologic variability on water supply and quality.

- *Unsustainably managed systems*: Water and land uses can add stresses that heighten vulnerability to climate change.

Some key impacts on Canadian water resources are described below:

- Most of southern Canada could experience declines in low-season river flows and lake levels and higher water temperatures. Snowmelt-dominated watersheds in western Canada will experience earlier spring peak flows and reductions in summer flows. These projected changes will have implications for water supplies, water allocation, hydroelectric production, waste assimilation and pollution concentrations, and freshwater ecosystems.

- There will be greater stresses on groundwater levels and quality, with levels declining in populated southern regions.

- Permafrost degradation may cause terrain slumping, small lake drainage, and increased erosion and sediment loads in rivers in affected areas.

- High concentrations of pollutants could occur in rivers when the flow is low and the point sources are important. Similar concentrations are possible when the flow is high and the runoff from agriculture and urban areas dominates. Increased frequency of short-duration, high precipitation intensities would result in an increased risk of biological contamination, greater soil erosion and sedimentation, and chemical pollution. More extended drier conditions in agricultural areas could reduce nitrogen leaching into groundwater and nitrate contamination.

The CCS identified the following knowledge gaps in the field of water resources: the effect of climate change and variability on extreme hydrologic events, regional hydrologic impact assessments, small lakes, hydrodynamic responses and ecosystem components, groundwater, and water quality. Several regional-scale projects have been initiated to address some of these gaps.

Potential Adaptation Measures

Management techniques, particularly those of integrated water resource management, can be applied to adapt to the hydrologic impacts of climate change (and to additional uncertainties) and thus lessen vulnerabilities. Adaptive responses include both supply-side (i.e., changes in water supply) and demand-side (e.g., differential pricing, public awareness campaigns, and statutory requirements) approaches and would offset some, but not all, of the impacts on water users and aquatic ecosystems.

Frequently identified adaptation options (no regrets or worth doing anyway measures) include:

- water conservation measures by all users;

- greater emphasis on planning and preparedness for droughts and severe floods;

- expanded efforts at water quality protection from agricultural, industrial, and human wastes;

- renewal of national monitoring efforts for water quantity and quality and climate; and

- improved procedures for fair allocation of water within basins and provinces and between jurisdictions, taking in-stream ecosystems into account.

Coastal Zone Management

Canada has three major coastlines: the Atlantic, the Pacific, and the Arctic. Each coastal area has unique ecological structures, development patterns, resource dependencies, and socio-economic structures. It is well documented that

a rise in global mean temperature will likely cause a rise in mean sea level because of thermal expansion of the waters, melting of glaciers, and a variety of other effects. Increases in sea level will vary regionally but, on average, are estimated to be between 0.20 and 0.65 m by 2100.

An increase in mean sea level will increase the flooding frequency in areas subject to occasional flooding and will introduce flooding to areas currently above the high tide levels. The highest water levels experienced in Canada are typically caused when high tides are augmented by storm surges. Sea level rise can also result in coastal retreat, depending on the physical nature of the coast.

A Canada-wide overview of coastal sensitivity to sea level rise, published by the Geological Survey of Canada in 1998 (Shaw *et al.*, 1998), shows regions of low, moderate, and high sensitivity along all three major coastlines. Among the most severely threatened areas are parts of the Atlantic coast, including central and northern Prince Edward Island. These are regions in which sea level is already rising, with demonstrable impacts; accelerated sea level rise under greenhouse warming is expected to exacerbate these impacts and lead to changes in adaptation requirements.

Potential Adaptation Measures

Among the main types of adaptation measures are:

- construction of physical protection structures, such as breakwaters, groins, dikes, floodwalls, and seawalls;
- natural shore stabilization measures, such as dune building, marsh building, artificial beach nourishing, and floodproofing; and
- land use regulations that restrict development along coastal areas.

Human Health and Safety

Climate change has the potential to have wide-ranging impacts on human health and safety. These impacts would arise by both direct pathways (e.g., exposure to changes in thermal stress and extreme events) and indirect pathways (e.g., increases in some atmospheric pollutants, pollens, and mould spores; malnutrition; increases in the potential transmission of vector-borne and water-borne diseases; stresses on the general public health infrastructure).

Potential Direct Health Impacts of Climate Change

The impacts of increased thermal stress can be illustrated using the examples of a major Canadian city: Toronto. Currently, in Toronto, there are about 19 heat-related summer deaths annually. This number could increase to 289 deaths annually by 2020 and to 563 deaths annually by 2050, depending on the presence or absence of public health measures, the increase in temperature, and the degree of acclimatization.

Although the impacts of extreme events are somewhat uncertain, an increase in the frequency and severity of such events could lead to increases in deaths, injuries, infectious diseases, and stress-related disorders, as well as increases in other adverse health effects associated with social disruption and environmentally forced migrations.

Potential Indirect Health Impacts of Climate Change

Changes in temperature and precipitation could lead to an increase in vector-borne diseases. For example, both western equine encephalitis and eastern equine encephalitis could expand their ranges in Canada. Malaria could potentially return to southern Canada, as local transmission by mosquitoes has occurred sporadically in the United States. Malaria may present a greater threat to Canada because of an increase in the drug resistance of the blood parasites and possible insecticide resistance of the mosquito vectors. Because of the lack of effective vaccines, dengue may also be of concern. Other diseases that may increase in geographic distribution/incidence include Lyme disease and Rocky Mountain spotted fever (which are caused by bacteria transmitted by ticks from various wild animals to humans) and hantavirus (which is carried by deer mice and can be transmitted by their feces or urine directly to humans).

Projected increases in temperature, in conjunction with rapid urbanization and increased energy consumption, could lead to serious degradation of air quality and associated respiratory problems. Increased ground-level ozone, for example, can impair the ability to

breathe and cause shortness of breath, chest pain, wheezing, and coughing. Repeated exposure to high levels of ozone over several months can permanently damage the lungs and cause chronic respiratory illness, increasing hospital admission rates and health care costs.

Changes in precipitation could also lead to an increase in water-borne illnesses caused by bacteria such as *Escherichia coli* and protozoan parasites such as *Cryptosporidium*, which are associated with animal and human fecal matter. Livestock manure presents a special problem, as poor waste management practices and extreme precipitation and runoff or flooding may lead to large-scale heavy surface water and groundwater contamination with both kinds of pathogens.

Additional health impacts might result from changes in water quantity, nutritional health (e.g., dietary changes resulting from relocation patterns and abundance of indigenous food sources), and increased numbers of environmental refugees.

Potential Adaptation Measures

For each anticipated adverse health impact, there is a range of social, institutional (e.g., enhanced and informed public health infrastructure), technological (e.g., health-oriented management of the environment, including air and water quality, food safety, urban and housing design, and surface water management), and behavioural adaptation options that could lessen that impact.

Based on the results of research to determine the extent of the potential impacts of summer heat on public health and identify unique weather-related thresholds for Toronto, the Toronto Atmospheric Fund and Toronto Public Health developed a Heat/Health Alert system. Implemented in the summer of 2001, this project involved the customization and operationalization of software that provides public health officials with a 48- to 60-hour warning before a potentially lethal air mass is predicted to arrive in the city. With this information, the Medical Officer of Health can issue a Heat Alert or the Mayor can issue a Heat Emergency and activate the Hot Weather Response protocol, which includes notifying the public on methods of keeping cool, identifying air-conditioned areas open to the public, delivering bottled water to these areas, and identifying agencies that will monitor vulnerable clients (such as seniors). This project, supported by the CCAF, is also investigating several methods of reducing the urban heat island effect.

Agriculture, Fisheries, and Forestry

Harvest levels in the agriculture, forestry, and fisheries sectors are sensitive to climate. Sustaining viable production levels will depend on the capacity of these sectors to cope with the projected rate of warming, changes in climate variability, and the prospects of imperfect responses, as well as their ability to counter projected decreases in water availability and increased threats of competition, disease, and other disturbances (e.g., fire and land use changes).

Agriculture

Agriculture is inherently sensitive to climate conditions. In Canada, an important dimension in dealing with the impacts of climate change on agriculture is the wide range of conditions for agricultural production between different regions. Traditionally, the impacts of climate change on agriculture have been assessed against current-climate average growing season conditions: average temperature and moisture, growing season length, and the timing of frosts. Agriculture is also influenced by other climate-sensitive variables, such as pests, insects, and plant diseases, which are not as yet captured in impact scenarios.

Analyses of agricultural vulnerability to climate change in Canada suggest that future climate variability and extreme weather events will result in the most impact, as is the case at present. The sector is generally well adapted to average conditions, but is susceptible to deviations from those conditions.

The anticipated impacts of climate change on agriculture in Canada include:

- an increase in the frost-free season, ranging from a minimum of one week to a maximum of nine weeks. Longer frost-free seasons will likely increase the rate of development of grain crops, reducing the time between seeding and harvesting and reducing the risk of frost-induced crop injury;

- a decrease in grain yields in the western Prairies by as much as 35%, and an increase in the eastern Prairies by as much as 66%;
- an decrease in oilseed yields as a result of increased crop moisture stress;
- larger seasonal moisture deficits in all regions, with the most severe situations anticipated in Ontario; and
- a northern expansion of agricultural potential.

Potential Adaptation Measures

There is a large range of potential adaptation options for Canadian agriculture. These will vary depending on the climate changes involved and on non-climatic forces such as the economy, politics, environment, and technology. Adaptation options include:

- diversifying crop and livestock types and varieties to reduce economic vulnerability to climate change;
- changing the location of crop and livestock production areas;
- changing farm practices to encourage soil moisture retention;
- diversifying agricultural household incomes;
- developing new temperature- and moisture-tolerant crop varieties;
- developing early-warning systems to inform farmers about the variability and probability of extreme climatic events;
- developing or enhancing irrigation and other water management systems; and
- modifying subsidy, support, and incentive programs to influence farm-level production and management practices.

Preliminary results of recent research funded through the CCAF suggests that there may be a need to consider how climate change risk management options fit into the general framework of agricultural decision making.

Forestry

Climate change will have both positive and negative impacts on Canada's forests. For a given area, the response of Canada's forests to climate change will depend on the physical geography, climate, forest type, disturbance history, forest management practices, and forest age-class composition. As a result, impacts will vary considerably across the country.

Anticipated negative impacts of climate change on forests in Canada over the next 50–100 years include:

- increases in the frequency and changes in the patterns of natural disturbances (such as fire and insects);
- a decrease in boreal forest area, biomass, and carbon stocks;
- a shift toward a younger age-class structure of the forest;
- major disruption and changes occurring along forest boundaries, particularly at the southern and northern boundaries;
- a shift, over the next century, of the geographic range of individual species. These ranges may shift approximately 300–500 km northwards, but the rate of movement may be limited by soil development and seed source;
- a reorganization of forest species composition;
- maximum potential migration rates that may be slower than the rate of climate change, resulting in large areas of transitory forest decline; and
- the combined impacts of increased pollutants (such as carbon dioxide, nitrogen, and tropospheric ozone) on forest health. These impacts are uncertain.

Anticipated positive impacts of climate change over the next 50–100 years include:

- replacement of some of the boreal forest by temperate forest, which grows (higher rotation species) and sequesters carbon faster;

- possible migration of boreal forests northward into areas that are now treeless;
- a possible increase in total standing biomass in some areas; and
- as trees grow/mature faster, more productive forests.

These changes, if they occur and if the forest industry, forest-dependent communities, and other stakeholders can adjust appropriately, could provide new opportunities, based, for example, on faster-growing species and new species distributions.

Potential Adaptation Measures

Predictability and uncertainty are major problems in adapting to climate change in the forestry sector. It will be necessary to first determine the sensitivity of forests to climate change and then identify the degree of change that would have a serious impacts (IPCC, 1998). Adaptation strategies may include:

- concentrating management efforts on sites that are less vulnerable;
- changing harvest schedules;
- adjusting replanting behaviour, including planting species more tolerant to variable climates;
- protecting existing forests by enhancing fire and pest prevention programs; and
- considering short rotation options to reduce risks during tree life span.

Fisheries

Fisheries are important sources of food, sport, and employment. In Canada, the commercial catch comes primarily from the oceans, while the recreational fishery is predominantly freshwater.

Under the assumption that climate change will mean a warmer, drier climate in most regions of Canada, possible impacts on regional fisheries include the following:

Pacific marine fisheries:

- lower and more variable sustainable harvests for southern salmon populations; and
- higher, more consistent sustainable harvests for northern salmon populations.

Atlantic marine fisheries:

- lower overall sustainable harvests for coastal and estuarine fish populations due to decreases in freshwater discharge and consequent declines in ecosystem productivity.

Arctic marine fisheries:

- increases in sustainable harvests for most fish populations due to increased ecosystem productivity, as shrinking of ice cover permits greater nutrient recycling.

Southern freshwater fisheries:

- decreases in sustainable harvests for many fish populations due to declining water levels in lakes, declining flow rates in streams, and reductions in nutrient loading and recycling for many lakes and streams on the Canadian Shield; and
- a decline in the proportion of overall sustainable harvest obtained from cold-water fish species, and a reciprocal increase in the proportion of overall harvest obtained from cold- and warm-water fish species.

Northern freshwater fisheries:

- increases in sustainable harvests for most fish species due to longer, warmer growing seasons and relatively small changes in water levels;
- a potential increase in the diversity of fish species that can be harvested sustainably due to increases in the diversity of thermal habitats available to support new species, expanding their ranges from the south; and
- a possible range contraction of Arctic-adapted fish species.

As is the case with many other sectors, possible adaptations to climate change within the fisheries sector will not be unique, and many may have already been implemented in response to other environmental changes. Adaptation strategies should work toward reducing vulnerability and incorporating robust management regimes that are less dependent on short-term production of fish stock.

Potential Adaptation Measures
Adaptation measures could include:

- modifying and strengthening fishery operations and fish monitoring programs to prevent overfishing and ensure sustainable harvesting;
- enhancing fish breeding to preserve the genetic diversity of fish populations;
- restocking areas with robust species;
- considering fish habitat needs in planning coastal development; and
- encouraging novelty fishery operations.

Communities and Infrastructure

Urban areas will also experience the impacts of climate change. Infrastructure requirements, water supply, and transportation are a few issues of significance to both urban and rural areas that are sensitive to future climates. As with the other sectors, community vulnerability to climate change in Canada varies from region to region. Proper city planning, design, operation, and management can help to optimize the beneficial climate change effects and minimize the adverse effects. Climate information is often neglected in municipal planning decisions for a variety of reasons, including lack of communication and appropriate climate information tools.

Canada's indigenous communities are also vulnerable to climate change. A distinct land-based subsistence and commercial economy exists in the Canadian north for which there are no short-term replacement prospects. Northern indigenous peoples would be affected by ecosystem shifts that may be outside the limits of historical memory. While adapting to environmental change is integral to the daily lives of northern peoples and a capacity to adapt is part of their livelihood systems, extreme events and unusual fluctuations in temperature can hinder their ability to maintain a subsistence lifestyle and can also create safety hazards.

Potential Adaptation Measures

Adaptation measures could include:

- incorporating climate change into land use, community, and transportation planning;
- revising building codes and regulations to reflect new climate conditions:
  - revising design parameters for flood protection infrastructure,
  - revising ventilation requirements for buildings,
  - implementing metered water pricing policies to reduce waste; and
- redesigning water cooling towers to reduce evaporation losses.

Recreation and Tourism

Tourism in Canada is highly seasonal: 43% of domestic tourism expenditures and 62% of international expenditures in Canada occur in the third quarter (summer). Temperatures 1°C above the summer norm increase domestic tourism expenditures by $405 million (4%) and 13 600 jobs. In contrast, temperatures 1°C above the winter norm decrease winter tourism expenditures, including Canadian expenditures with travel agents (presumably to warm weather destinations). Above-normal precipitation does not appear to have a significant impact on tourism expenditures.

Climate change is likely to extend the summer outdoor recreational season, resulting in increased demand for summer recreational facilities. Sea level rise could reduce beach area in marine coastal areas and result in increased maintenance costs. Projected lower water levels in freshwater lakes and rivers could result in existing recreational facilities being located further from the shoreline. In some areas, the lower freshwater levels combined with warmer summer temperatures may result in increased algal growth, impairing the recreational experience and water quality.

Projected increases in temperatures may lengthen the summer sports season across Canada (e.g., golfing season in Quebec may be extended by up to three to four weeks). Recreational fishing, hunting for game and waterfowl, and bird watching are also likely to be affected, as fish and wildlife may be displaced due to habitat loss or increased competition.

Canadians spend more on skiing (over $500 million a year in South Georgian Bay communities alone) than on snow removal, and snowmobiling in Ontario is worth over $1 billion a year (trails operated by the Ontario Federation of Snowmobile Clubs generated approximately $932 million in economic activity in 1998). Changes in snow condition would have

significant economic and social impacts for communities with winter recreational industries.

Potential Adaptation Measures

Tourists and sports enthusiasts may be expected to adapt to changing climate conditions by using alternative recreational locations, reducing or stopping participation, and substituting activities. The recreation and tourism industry may be able to adapt by creating a capacity for flexibility in relocating facilities, taking advantage of advances in equipment technologies, and diversifying their offerings — for example, providing a number of recreational alternatives having a range of climatic requirements and sensitivities.

NEXT STEPS

Impacts and adaptation research has been recognized by the Government of Canada as a necessary part of any comprehensive approach to dealing with the climate change challenge. Several initiatives are in the planning or very early stages of implementation.

In 2000, the Government of Canada announced an extension of the CCAF program for another three years and additional funding over five years through Action Plan 2000. Through these funds, $37.5 million has been allocated to impacts and adaptation.

As part of the renewed CCAF program, and recognizing that the community level is where many decisions on primary adaptation will occur, the impacts and adaptation component of the CCAF has identified community-based research and communication as a priority for the next phase of funding. A series of case studies on representative communities will be undertaken with the aim of developing a methodology that would be applicable across the country and that would help communities identify their climatic vulnerabilities, regional or sectoral sensitivities, and best practices for adaptation.

Other major initiatives include development of a national climate change impacts and adaptation research network, as well as building of research capacity. Building on the results of the CCAF, the new program will highlight understanding of both climatic sensitivity and adaptive capacity. It will address priority issues identified on regional and sectoral bases and provide information needed for decision makers at all levels to reduce Canada's vulnerability to climate change through adaptation.

Recognizing the growing need for domestic action on adaptation, Canada has also taken steps in the national climate change process to develop a policy framework for adaptation.

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CHAPTER 7 Financial Resources and Transfer of Technology

INTRODUCTION

Climate change is an issue that requires cooperation on a global scale to develop and implement solutions. Canada remains committed to assisting and working with other countries to combat climate change in fulfilment of its obligations under Article 4 of the Framework Convention on Climate Change (FCCC). Canada has taken significant action in this regard through both multilateral and bilateral channels and is continuing to increase its efforts. This chapter outlines Canada's financial contributions and technology transfer efforts for the past three years.

Canada also looks forward to reporting in the future on the accomplishments to be achieved through its $100 million Canada Climate Change Development Fund, announced in the Government of Canada's 2000 budget. This fund will further increase Canada's ongoing international assistance and technology transfer programs. The goal of the fund is to contribute to Canada's international objectives on climate change by promoting activities in developing countries that seek to address the causes and effects of climate change, while at the same time contributing to sustainable development and poverty reduction.

In the same budget, Canada also announced a $15 million contribution toward the establishment of the World Bank's Prototype Carbon Fund (PCF). The PCF is pioneering approaches to reduce emissions within the context of the FCCC negotiations in a "learning by doing" mode that will facilitate and mobilize climate-friendly investment in developing countries and economies in transition.

FINANCIAL CONTRIBUTIONS

Canada supports international efforts to develop climate change solutions through financial contributions to the Global Environment Facility (GEF), World Bank, United Nations programs, regional development banks, and other international institutions. Tables 7.1 and 7.2 summarize Canadian contributions to these institutions and programs, and a brief description of some of the work supported by this assistance follows.

In addition to its ongoing development assistance efforts, Canada provides new and additional funding for climate change to the GEF. Operating as a financial mechanism of the FCCC, the GEF provides financial resources on a grant basis for enabling, mitigation, and adaptation activities in recipient countries. It provides this assistance in accordance with guidance from the Conference of the Parties (CoP) on its policy, program priorities, and eligibility criteria, and it reports to each meeting of the CoP. Climate change projects funded by the GEF focus on, among other things, reducing the costs of low greenhouse gas (GHG) emitting energy technologies, removing barriers to energy conservation and energy efficiency, and promoting environmentally sustainable transport.

Through its core funding and special contributions to the United Nations Development Programme (UNDP), Canada supports projects that promote environmentally sound development policies to improve the livelihoods of some of the world's poorest citizens, while encouraging economic growth and increasing countries' ability to adapt to climate change.

Canada also supports the efforts of the United Nations Environment Programme (UNEP) to build capacity in environmental assessment and environmental monitoring, to provide information and support research in early-warning systems, and to transfer technologies to developing countries, with a special focus on Africa.

Canada supports several regional development banks whose goals include fostering economic growth, supporting human development, improving the status of women, and protecting the environment. An example of the type of contributions made toward addressing climate change is the Least-Cost Greenhouse Gas Abatement Strategy Project of the Asian Development Bank. This project was designed to assist 11 member countries (Bangladesh,

Table 7.1 Financial Contribution to the Global Environment Facility (GEF)

	Contribution (millions of Canadian dollars)	
	1994-1998 First Replenishment	1998-2002 Second Replenishment
Global Environment Facility	111.11	122.09

Table 7.2 Financial Contributions to Multilateral Institutions and Programs

Institution or Program	Contribution (millions of Canadian dollars)		
	1996-97	1997-98	1998-99
Multilateral Institutions			
1. World Bank/International Monetary Fund [a]	232.09	221.46	356.75
2. International Finance Corporation [b]	9.54	0	0
3. African Development Bank [c]	40.66	56.72	70.49
4. Asian Development Bank [c]	4.58	43.06	43.06
5. European Bank for Reconstruction and Development [c]	1.00	2.97	10.23
6. Caribbean Development Bank [c]	0	0	4.07
7. Inter-American Development Bank [c]	5.70	5.70	0
8. United Nations Development Programme (Core Funding)	43.27	41.25	41.30
9. United Nations Environment Programme (Environment Fund)	1.10	1.10	1.10
- Trust Fund and Counterpart Contributions	0.50	0.50	0.50
10. UNFCCC			
- Core Funding	0.50	0.50	0.50
- Voluntary Contributions	0.05	0	0
Multilateral Scientific, Technological, and Training Programs			
1. World Meteorological Organization	2.07	1.95	2.36
2. InterAmerican Institute for Global Change Research	0.15	0.15	0.15
3. IPCC	0.10	0.10	0.10

(a) Amounts represent encashment of notes for the International Development Association and payments to the International Monetary Fund's Enhanced Structural Adjustment Facility; amounts do not include contributions to various trust funds held by those organizations.

(b) Amounts represent capital subscriptions to the International Finance Corporation and exclude contribution to trust funds held by the corporation.

(c) Amounts are issuances for concessional funds.

People's Republic of China, India, Indonesia, Republic of Korea, Mongolia, Myanmar, Pakistan, Philippines, Thailand, and Vietnam) in meeting their commitments under the FCCC. One activity involves the preparation of a portfolio of GHG abatement projects and national plans embodying country development objectives.

Canada contributes to the Climate Change Knowledge Network, which is coordinated by the International Institute for Sustainable Development. This network brings together 14 organizations from developing, transitional, and developed countries. It aims to promote a more effective, sustainable, and equitable global climate change regime through capacity building, collaborative research, and communication on issues such as the Kyoto mechanisms, adaptation, and technology transfer. Most recently, the network published a guide for developing country negotiators, entitled On Behalf of My Delegation, which has been a successful training tool.

Canada contributes financial assistance and scientific expertise to the Intergovernmental Panel on Climate Change (IPCC), which was created by UNEP and the World Meteorological Organization to assess available scientific information and potential climate change impacts and to formulate strategies to respond to climate change. More than 30 Canadian scientists and experts have contributed to the IPCC's Third Assessment Report and to its Special Reports on technology transfer and other subjects.

Canada also contributes financially to the Climate Technology Initiative (CTI). The CTI was launched in 1995 by 23 Organisation for Economic Co-operation and Development (OECD) countries together with the International Energy Agency (IEA) and the European Commission. The mission of the CTI is to promote the objectives of the FCCC by fostering international cooperation for accelerated development and diffusion of climate-friendly technologies and practices for all activities and GHGs.

CAPACITY BUILDING AND TECHNOLOGY TRANSFER

A number of Canadian programs aim to build capacity and transfer technologies that enable action on climate change.

International Assistance Programs

The purpose of Canada's official development assistance (ODA) is to support sustainable development in developing countries in order to reduce poverty and to contribute to a more secure, equitable, and prosperous world. The Canadian International Development Agency (CIDA) is the main Canadian government department responsible for delivering ODA. The list of countries eligible for Canadian ODA is based on the one established by the Development Assistance Committee of the OECD. More than 100 countries are recipients of Canadian ODA, but about 30 of these receive the bulk of Canadian assistance. The ODA budget averaged approximately $2.7 billion per year in the years 1996–97 through 1998–99.

Although its work is global in scope and encompasses a wide range of sectors, CIDA pursues the following six priorities in fulfilling its ODA mission: Basic Human Needs; Women in Development and Gender Equality; Infrastructure Services; Human Rights, Democracy, Good Governance; Private Sector Development; and Environment. Specific activities and projects are delivered through a number of channels. The largest, in terms of dollar amount, are typically the bilateral or country-to-country channel (whereby programming is developed in response to requests from the recipient country government) and the multilateral channel (contributions to relevant multilateral institutions, as described above in the "Financial Contributions" section). Another major channel is the Partnership program, whereby eligible Canadian organizations deliver projects in collaboration with recipient country partners. Assisting developing countries in meeting the challenges posed to their sustainable development by climate change is integral to CIDA's mandate, and many CIDA projects contribute to combatting climate change while at the same time realizing other benefits in areas such as health, food security, and energy efficiency.

The International Development Research Centre (IDRC) is another Canadian government entity that participates in the delivery of ODA. IDRC supports research in the developing world, with emphasis on funding projects identified and carried out by scientists in those countries. IDRC focuses most of its funding toward research carried out in least-developed countries. Therefore, IDRC's greatest contribution to the climate change challenge lies in its broad Environment & Natural Resources Management program, which incorporates research on improved agricultural and forestry practices, watershed management, land and water conservation, measures to combat desertification, and protection of biodiversity, among other issues. Funds devoted to this kind of research have averaged about $15 million per year. All of this research serves to increase the quality and quantity of forest and agricultural sinks, which generate global benefits because of their uptake of carbon dioxide (CO_2), and which also result in local benefits because they increase resilience to drought and other adverse climatic conditions. In addition, IDRC devotes a part of its research funding to projects on local water use, rain-fed agriculture, and recycling systems, which have the effect of reducing methane (CH_4) emissions.

Table 7.3a Bilateral and Regional Financial Contributions Related to the Implementation of the Convention, 1997
(000 000s of Canadian dollars)

Recipient Country/ Region	Mitigation[a]						Adaptation		
	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Argentina	0.12			0.23					
Brazil	8.12	0.10	0.10	0.61	3.09	1.54	0.61	0.10	0.61
Cameroon			3.94				7.88		
Chile	1.20	1.80			1.16				
China	33.60	1.95		2.00	4.31	15.16	2.63	1.69	
Colombia	3.52	1.50							
Costa Rica	0.37		0.38				0.75		
Cuba	0.65		0.68						
Dominican Republic			1.06	2.00					
Ecuador			0.11						
Egypt	0.72						2.88		
El Salvador			0.42	0.18					
Ethiopia							0.40		
Guatemala	0.11								
Guinea	67.45								
Haiti	6.91								
Honduras	1.20		5.21	2.40			1.61		
India	5.92	0.55	0.20	0.06		2.09	2.01		0.19
Indonesia	0.55		1.97		0.55	0.55	2.29		
Madagascar	0.00		0.15						
Mali	2.46						2.46		
Mexico			0.10						
Nicaragua			0.04						
Niger			0.06						
Pakistan	21.35		2.82			8.15	0.02		
Peru	0.50		0.08	0.16	0.50	1.00			
Philippines				0.07					
Russia	1.57					1.25	2.80		0.42
Uganda			0.07						
Ukraine			0.11		0.04	0.04	0.08		
Zimbabwe	2.75					2.75	0.23		
Regional — Asia			0.55	0.49					
Regional — Africa	50.30						3.14		
Regional — Americas	6.78			0.12	1.53	1.53	0.77		
Multi-regional	0.20		3.11	2.76		0.10	0.28	1.47	
TOTAL	**216 36**	**5.90**	**21.14**	**11.07**	**11.18**	**34.14**	**30.84**	**3.27**	**1.22**

(a) Mitigation includes capacity building for mitigation.

Note: Estimated contributions in 1997 across all sectors: Cdn $33.51 million.

Canada also maintains an active program of official assistance, separate from its ODA program, to Central and Eastern Europe and to the former Soviet Union, as transitions are being made to market-based economies. This program works through partnerships that transfer knowledge, skills, and technology.

Some examples of projects related to climate change executed under Canada's international assistance programs are briefly described below. Also, Table 7.3 contains estimates of the value of the proportion of numerous CIDA projects addressing climate change in developing countries and countries with economies in transition. While not exhaustive, Table 7.3 does indicate the wide array of assistance that Canada provides to global efforts to combat climate change. In addition, Table 7.4 provides a more detailed description of two technology transfer

Table 7.3b Bilateral and Regional Financial Contributions Related to the Implementation of the Convention, 1998
(000 000s of Canadian dollars)

Recipient Country/ Region	Mitigation[a]						Adaptation		
	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Argentina	0.13			0.23					
Bolivia	4.00			0.26					
Brazil	3.95	0.03	0.03	0.64	3.28	0.91	0.85	0.03	0.65
Cameroon			11.01				3.89		
Chile	0.30	0.45	0.76	0.67	0.79				
China	32.02		0.29	1.76	5.99	14.84	6.60	2.34	
Colombia	2.18	1.40				0.85			
Costa Rica	1.56		0.69	0.39			3.12		
Cuba	1.01	0.34	0.04						
Dominican Republic	0.00		1.01	2.15					
Ecuador			0.16	0.00					
Egypt	0.47						1.87		
El Salvador			0.63	0.27					
Ghana			0.85	1.03					
Guatemala	0.11								
Guinea	75.87								
Haiti	7.10								
Honduras	1.75		7.55	3.49			2.25		
India	7.74	0.81	0.73	0.14		1.86	3.43		0.43
Indonesia	0.67		0.50		0.67	0.67	1.89		
Jamaica	0.14		0.07						
Latvia					0.14				
Lebanon					0.05				
Madagascar			0.03						
Mali							3.91		
Mexico			0.54	0.04					
Morocco					1.45				
Nepal	0.13		0.38					0.25	0.08
Nicaragua			1.19						
Niger			0.11						
Pakistan	17.85		2.66			7.12	0.08		
Papua New Guinea			0.23						
Peru	0.50		0.07	0.14	0.50	1.00			
Philippines				0.42					
Poland	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Russia	0.01		0.38				0.84		0.08
Senegal							0.28		
Trinidad & Tobago					0.26				
Turkmenistan	0.05								
Uganda			0.37						
Ukraine			0.56		0.02	0.02	0.03		
Venezuela	2.47								
Zimbabwe	3.72					3.72	0.18		
Regional — Asia	0.18		3.05	1.15	0.89		0.75		0.43
Regional — Africa	18.72						0.92		
Regional — Americas	18.15		0.35	0.62	2.33	2.33	3.20		
Multi-regional	0.93		4.77	6.21		0.04	3.32	3.83	
TOTAL	**201.72**	**3.04**	**39.00**	**19.62**	**16.40**	**33.37**	**37.41**	**6.47**	**1.69**

(a) Mitigation includes capacity building for mitigation.

Note: Estimated contributions in 1998 across all sectors: Cdn $35.87 million.

Table 7.3c **Bilateral and Regional Financial Contributions Related to the Implementation of the Convention, 1999**
(000 000s of Canadian dollars)

Recipient Country/ Region	Mitigation[a]						Adaptation		
	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Argentina	0.91			0.24	1.13				
Bangladesh	1.20								
Belarus/Russia									0.10
Bolivia	5.50		0.12	0.45					
Brazil	1.88	0.03	0.03	0.30	1.46	0.54	0.63	0.03	0.32
Cameroon			13.25				4.09		
Chad	0.08								
Chile			1.30	0.63					
China	21.22		0.03	1.37	6.61	15.40	7.76	1.90	
Colombia	3.53	2.35				0.05			
Congo	1.95								
Costa Rica	2.93		1.31	0.35			5.85		
Cote d'Ivoire		0.14							
Cuba	3.68	0.70	0.98						
Dominican Republic			2.31	1.71					
Ecuador			0.41	0.33					
Egypt	0.45						1.79		
El Salvador			0.77	0.41					
Ethiopia							0.41		
Fiji			0.22						
Ghana			0.95	0.67					
Guatemala	0.79		0.25						
Guinea	23.46								
Haiti	15.14		0.20						
Honduras	1.89		6.00	2.90			1.90		
India	11.99	1.27	0.59	0.09		2.85	3.59		0.27
Indonesia	0.70		1.03		0.70	0.70	1.77		
Jamaica	0.20		0.10			0.00			
Kazakhstan	0.82					0.22			0.07
Latvia					0.44				
Lebanon					0.13				
Madagascar			0.01						
Mali	3.74		0.41	0.14			3.74		
Marshall Islands							0.03		
Mexico			0.22	0.01					
Morocco					1.58				
Nepal	0.05		0.15					0.10	0.03
Nicaragua			1.14						
Niger			0.02						
Pakistan	9.41		1.52			3.87	0.02		
Peru	1.30		0.14	0.28	1.30	2.60			
Philippines			0.52	0.53				0.29	
Poland	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Russia	1.22		1.78		0.22	0.97	1.66		0.67
Trinidad & Tobago					0.13				
Tunisia							0.27		
Turkmenistan	0.08								
Uganda			0.16						
Ukraine			0.17						
Venezuela	0.35								
Vietnam	0.01			0.02					
Zimbabwe	3.48					3.48			
Regional — Asia	0.03		9.46	3.37	0.16		1.87		1.69

Table 7.3c ***(continued)***

Recipient Country/ Region	Mitigation[a]						Adaptation		
	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Regional — Africa	75.00						4.43		
Regional — Americas	29.36		0.40	0.07	0.61	0.61	5.85		
Multi-regional	2.65		14.44	16.08		0.02	2.76	0.99	
TOTAL	**225.04**	**4.52**	**60.42**	**29.97**	**14.52**	**31.36**	**48.47**	**3.34**	**3.18**

(a) Mitigation includes capacity building for mitigation.

Note: Estimated contributions in 1999 across all sectors: Cdn $42.08 million.

success stories, which are representative of the broad scope of both soft and hard technologies that are being transferred through both small- and large-scale assistance projects.

Remote Sensing in South America

GlobeSAR-2 (RADARSAT) is a Canadian initiative to transfer remote sensing technology to South America. CIDA funds this project, which is executed by the Canada Centre for Remote Sensing Technology and Radarsat International. RADARSAT technology has the capability to distinguish between different types of surface textures, as related to ground cover, crop type and maturity, forest types and clearances, and level of moisture. This results in a greater ability to assess, monitor, and adapt to the impacts of climate change, such as drought and desertification, flooding, changes in coastline and ground cover, and soil productivity.

Energy Sector Management in Latin America and the Caribbean

CIDA supports the UNDP/World Bank Energy Sector Management Assistance Program in Latin America and the Caribbean. The goal of this project is to accelerate the introduction of cleaner fuels by assessing the impact of new environmental requirements, increased petroleum product demand, sector reform, and changes in trade patterns in the downstream sector on the refining industry. Improvements in local air quality and public health in urban centres in Latin America and the Caribbean will occur in addition to the reductions in global GHG emissions.

Cuba–Canada Environmental Restoration Partnership

The Cuba–Canada Environmental Restoration Partnership (CCERP) project focuses on a 700-ha parkland in Havana, Cuba. Through strong community involvement in environmental education and restoration projects, CCERP strengthens the capacity of local groups to deliver focused environmental education programs involving Havana schoolchildren. CCERP will also contribute to the environmental regeneration of a denuded area of the Almendares River through the establishment of a permanent plant nursery. The result of the project will be a greater capacity of the local population to address climate change issues, as well as the regeneration of a carbon sink.

Tree Link, Southeast Asia

In response to the disastrous 1997 forest fire season and recent flooding, this project builds the capacity of the region to manage its forest resources. Specifically, it supports the development and implementation of policies and practices for forest renewal, conservation, and protection. Improved management practices can help prevent forest fires due to increased temperature, improve the overall health of the ecosystem, and preserve and improve the livelihoods of the people who depend on this valuable natural resource.

Energy Efficiency in Buildings, China

Rapid economic growth in China has been followed by greater demands for energy for heating, cooling, and hot water in buildings. Total energy consumption by buildings is expected to grow 6% a year, far outstripping

Table 7.4 Description of Selected Projects or Programs that Promoted Practicable Steps to Facilitate and/or Finance the Transfer of, or Access to, Environmentally Sound Technologies

Project/program title: Global Links to Climate Change

Purpose: The purpose of this project is to improve and protect the quality of life of the people of Ecuador by raising the awareness of civil society in the areas of climate change, alternative transport, sustainable development in the Amazon, and alternative energy.

Recipient country	Sector	Total funding	Years in operation
Ecuador	Environment	$300 000	1998–2001

Description: This project focuses on the transfer of soft technologies at the community level in Ecuador. The Toronto Environmental Alliance works, in partnership with Acción Ecológica, a South American environmental non-governmental organization (NGO), to strengthen the capacity of civil society, particularly indigenous peoples, women, and youth; foster sustainable development in Ecuador; and contribute to the reduction of air pollution. This project empowers the public in Ecuador to change behaviours and effect government policies to help reduce GHGs.

Specific results of this project include increased awareness of cycling as an alternative mode of transportation, improved urban infrastructure for cycling, increased awareness of alternative energy such as solar power, and an increase in demand for and use of alternative energy by consumers.

Activities include development of educational documents, videos, CDs, and radio broadcasts; and national workshops and training tools for awareness raising regarding alternative transport, oil production activities in Ecuador, and climate change. As a complement, some of the activities also focused on introducing measures to reduce consumption of petroleum and its derivatives in both Canada and Ecuador.

Factors that led to project's success: The strength of this project lay in the strong partnership between the Canadian and South American NGOs, where activities were driven by the needs of the southern organization. Also, activities addressed both the supply and demand issues of energy consumption from a northern and southern perspective, making this a holistic approach.

Technology transferred: Models for engagement of civil society in the climate change process and expertise in the production of educational materials.

Project/program title: India–Canada Environment Facility (ICEF)

Purpose: This umbrella project seeks to enhance Indian capacity to implement sustainable activities in the energy and water sectors. There are 20 projects currently under way, a number of which have important climate change components.

Recipient country	Sector	Total funding	Years in operation
India	Energy, water	$72 000 000	1993–present

Description: ICEF is a development cooperation project of the Government of India and the Government of Canada, which was established in 1993 following an MOU between the two governments. Funding is provided by CIDA through a counterpart fund.

ICEF's mandate is to enhance the capacity of Indian private and public sector organizations to undertake environmentally sustainable development and management of land, water, and energy resources; to provide support for programs that specifically address the interrelationship between poverty and environmental degradation, especially as it affects women; and to provide support for public awareness of environmental issues and community participation and for community-based management of land, water, and energy resources.

Several ongoing subprojects funded under ICEF address mitigation of GHGs and adaptation to the adverse effects of climate change. For example:

- The energy sector of the ICEF includes projects on renewable energy, energy conservation and efficiency, fuel-efficient devices, and technologies leading to savings on fuelwood, thus reducing pressure on the environment. Technologies such as solar lanterns, wind turbines, and improved stoves are being introduced to many villages in rural India.
- In the natural resources sector, projects dealing with watershed management, forest conservation and afforestation, coastal zone management, and protection of coastlines and water resources have the benefit of sequestering carbon as well as contributing to efforts to adapt to the potential adverse impacts of climate change, such as coastline erosion and water shortages.

In addition, recently approved projects will contribute to the implementation of the FCCC in the areas of forest/land regeneration and conservation, integrated water resources management, coastal zone protection, energy conservation, energy efficiency technologies in non-formal industries, renewable energy, and education and capacity building.

Table 7.4 ***(continued)***

Factors that led to project's success: As this is a counterpart fund, it is locally managed in India and driven by the demands of the Indian public and private sectors. Because of this local buy-in, ICEF's subprojects have been able to increase acceptance and support for selected water and energy technologies by users and the government. Almost all project partners have shown improved staff capacity. Projects are selected for a combination of technical and economic feasibility, direct contributions to sound environmental management, sustainability of activities and results, social and cultural effects, with particular emphasis on the role of women, and institutional capacity.
Technology transferred: The technologies transferred are varied and include biogas plants, domestic energy-saving devices (solar cookers), energy-efficient commercial equipment (burner/dryers), and methods of carbon sequestration in grasslands and forests.
Impact on GHG emissions/sinks: Increased use of energy-saving and renewable energy technologies and restoration and conservation of forests and grasslands will result in the mitigation of GHGs through reduced emissions as well as sequestration.

energy production, planned at 2–4% per year. To reduce energy demands, China aims to improve energy efficiency in buildings. These activities will assist China's Ministry of Construction in developing energy efficiency standards for buildings, based on Canadian technology, thereby reducing GHG emissions. Co-benefits include improved local air quality, resource conservation, and transfers of technology to other sectors.

North Sulawesi Water Resources Institutional Development Project, Indonesia

This project aims to improve the management, design, construction, monitoring, and flood control in the water sector. Improvements toward sustainable water management contribute to increased capacity of local groups to adapt to the effects of climate change, such as drought, floods, and extreme weather events.

Southern Africa Development Community (SADC) Industrial Energy Management Project

This project is increasing the capacity of consulting engineers, industrial firms, and educational institutions in the SADC region to develop industrial energy management programs, undertake energy efficiency projects, and offer education and training programs in energy conservation and management. Building the capacity of local professionals is a sustainable means of preventing and reducing GHG emissions as well as those of local air pollutants.

Environmental Rehabilitation and Food Security in Mali

Mali has experienced several years of drought and desertification, which are the main causes of food insecurity in the region. The task of land management has been decentralized in recent years and is now a local responsibility. This project builds capacity in local, decentralized institutions for environmentally sound natural resource management and supports specific environmental interventions as they relate to both adaptation to desertification and improved food production.

Reducing Vulnerability

In the wake of Hurricane Mitch, IDRC launched a unique research program to identify options for recovery that would simultaneously improve natural resources management and provide greater resistance to future events on the scale of Mitch. This program of some 60 small grants covered all the affected areas in Central America and was widely regarded as a successful effort to reduce vulnerability to future extreme weather events.

International Model Forest Network

Canada's domestic Model Forest Program has been expanded into a global network of model forests. In the three years since the Second National Report, the International Model Forest Network has expanded considerably, and it is now widely recognized as an important way to

increase democracy and promote more sustainable management of natural resources in rural areas, thus ensuring the sustainable management of important carbon sinks. It is based on a multistakeholder approach to forest management that was developed in Canada. This international program is supported by IDRC, CIDA, the Canadian Forest Service, and the Department of Foreign Affairs and International Trade. Model forests now exist in several countries, including Russia, Chile, and Mexico. Last year, Mexico created its third Model Forest to protect the area where monarch butterflies breed west of Mexico City, while permitting local development. In 2000, Chile created its second Model Forest, and two others are in the planning stage in Argentina. Most recently, a decision has been taken to decentralize operations of the Model Forest Network. The secretariat will remain in Ottawa, but regional nodes, starting with one in Latin America, will be created and are expected over time to become financially self-sustaining. The International Model Forest Network Secretariat is funded at a level of approximately $3 million per year.

International Network for Bamboo and Rattan (INBAR)

Bamboo and rattan are critical to the economies and the ecologies of many Asian, especially southeast Asian, countries. They are equally valuable as market commodities and as ground cover, but they are vulnerable to climate change. For many years, IDRC supported research on various options to improve the conservation and use of bamboo and rattan. To concentrate these efforts, an international centre was created where this type of research could be focused, and from which research results could be disseminated. In collaboration with the Government of China, INBAR was established in Beijing and continues to be supported by IDRC, among other donors. This network is making a significant contribution to the ability of Asian nations to protect themselves and their economies during an era in which changes in climate can be expected.

Technology Early Action Measures (TEAM) Program

Since 1998, the Technology Early Action Measures (TEAM) component of Canada's Climate Change Action Fund has allocated $60 million to fund technology projects that will reduce GHG emissions domestically and internationally while sustaining economic and social development. TEAM is led by Natural Resources Canada (NRCan), Environment Canada, and Industry Canada.

TEAM has provided a unique set of international projects that demonstrate the benefits of linking Canadian companies' business strategies and technology capabilities with global business opportunities and with Canada's international policy objectives to assist developing countries. TEAM international projects have complemented the federal government's international mandates by developing partnerships with Canadian companies and linking their technology to private and public sector partners in a growing number of developing countries. This has served to demonstrate, on the international scene, that GHG reduction and economic development can be done together. TEAM has also provided an experience base so that Canada and its partners can develop the capacity to utilize real projects for appropriate development through the Clean Development Mechanism/Joint Implementation (CDM/JI) under the Kyoto Protocol. Some examples of international TEAM projects follow.

Natural Gas Vehicles in Romania

The project will assist two Romanian companies in using a natural gas fuel-injection system to convert automobiles in Romania to natural gas. Total projected GHG emissions reductions are expected to amount to well over 8 000 t per year.

Automated Turbine Controls in China

This project will see the transfer of small, automated turbine control units to five small hydro plants in China. Through improved energy efficiency and the displacement of energy produced by coal, the five demonstration sites are expected to reduce carbon dioxide emissions by approximately 30 000 t per year.

Natural Gas Auto-Rickshaws in Pakistan

The goal of this project is to promote the conversion of auto-rickshaws to natural gas using natural gas conversion technology. Converting one of Pakistan's most important sources of public transportation to natural gas will reduce annual carbon dioxide emissions by 21% compared with existing technology.

Greenhouse Gas Emission Reduction Through Energy Management in Brazil
This project will develop and implement energy management demonstration projects in six industry sectors in Brazil that represent about 50% of total manufacturing establishments. The initial projects have the potential to reduce emissions by a total of 8 000 t of carbon dioxide per year.

Methane Recovery from Landfills, Bio-reactor Landfill Cells Demonstration Project, Egypt
Taking place in Cairo, this project will demonstrate the recovery of landfill gas (mainly methane), which can then be used for generating power. Waste management is a pressing issue in cities around the world. The Greater Cairo area alone generates up to 12 800 t per day of solid waste. Landfill gas recovery and utilization represent a means for controlling global warming, first by reducing the emissions to the environment, and second by generating energy to reduce fossil fuel consumption. This project has the potential to reduce GHG emissions by approximately 500 000 t a year.

Clean Development Mechanism/Joint Implementation (CDM/JI) Office
Canada's CDM/JI Office, housed within the Department of Foreign Affairs and International Trade, aims to enhance Canada's capacity to participate in opportunities offered by the CDM/JI flexibility mechanisms under the Kyoto Protocol and to obtain emissions reduction credits according to international rules and guidelines. CDM/JI projects can benefit developing countries and countries with economies in transition by providing clean technologies and capacity-building assistance and by contributing to emissions reductions. The CDM/JI Office's mandate includes building awareness among Canadian entities, promoting cost-effective opportunities, lowering transaction costs, and engaging developing countries. Activities by the CDM/JI Office have included:

- acting as the focal point for Canadian review of potential activities implemented jointly;
- developing communications and outreach, such as an information package on climate change and the CDM/JI mechanisms distributed to all Canadian diplomatic posts and other international contacts, awareness-raising presentations at Canadian and international conferences and workshops, and meetings with government officials and industry representatives in Africa, Asia, and Latin America;
- sponsoring workshops on capacity building and financing for the clean development mechanisms in Africa, Asia, and Latin America;
- conducting market studies;
- establishing a database of companies and project activities; and
- conducting discussions with a number of countries to develop generic and project-specific bilateral agreements for joint projects.

Canadian International Technology Initiative
Key objectives of this initiative are to identify and develop climate change technology transfer projects overseas, facilitate the expansion of market opportunities for Canadian companies, and provide a sound analytical base for future international technology marketing activities.

The program consists of two components. The Technology Transfer and Promotion component features four initiatives, which comprise 80% of the program and aim for short- to medium-term impacts by identifying projects and partners to promote technology transfer and securing possible emissions credits. The four initiatives are:

- trade facilitation through the Canadian Initiative for International Technology Transfer, which will promote assistance for the identification and development of climate change technology projects for demonstration in developing countries, with a focus on the commercial and capacity-building aspects of projects;
- supporting the posts through the establishment of Climate Change Technology Promotion Officers in Asia, Latin America, and Eastern Europe. This five-year pilot

program will focus on assisting Canadian industry in marketing Canadian climate change technologies and expertise;

- technology showcasing through enhancement of the successful Canadian Climate Change Solutions CD and Web site hosted by Industry Canada; and

- workshop and missions dedicated to climate change issues, industries, and technologies, which will serve as a forum to encourage and build effective partnerships.

The Analytical Support component will help refine marketing strategies to take into account changing market conditions. It comprises two initiatives:

- international technology market analysis to examine mid- and longer-term technology needs of international markets; and

- statistical monitoring of climate change technologies to help determine the availability of climate change technology solutions, evaluate current exports by industry, region, and destination, identify barriers to export growth, and record expenditures on innovation and research and development (R&D).

Trade Team Canada Environment

The Government of Canada, in its drive toward achieving a sustainable balance between environmental and economic activities, has created Trade Team Canada Environment. Through the use of climate change workshops and trade missions, Trade Team Canada Environment is promoting Canadian climate change technologies, services, and products around the world, in particular to developing countries. These workshops, falling under the Kyoto Protocol's clean development mechanisms, increase discussion between government and industry. In addition to offering participating companies the ability to obtain information about potential markets and business opportunities, climate change workshops provide one-on-one networking and matchmaking opportunities for government and industry participants.

CANMET Energy Technology Branch

The CANMET Energy Technology Branch (CETB) is the main R&D arm of NRCan and is involved in research, development, and deployment of clean energy technology. CETB is involved in technologies related to buildings, community and industry energy efficiency, renewable energy, alternative transportation fuels, and advanced combustion. NRCan has been working closely with developing countries to undertake joint research and pave the way for successful technology transfer by Canadian companies. It has also been instrumental in helping Canadian companies transfer clean energy technologies and establish joint ventures in developing countries.

NRCan's role in technology transfer has included business development and establishment of linkages with key government officials, matching of Canadian companies with foreign partners, signing of government-to-government memoranda of understanding (MOUs) to help establish a framework for collaboration, R&D funding to adapt technology to developing-country markets, and provision of funding for demonstration projects. Examples of this type of involvement can be found in India (wind energy, boilerhouse retrofit), China (photovoltaic, solar), Romania (natural gas vehicles), Poland (low-head hydro), Nepal (small hydro), and Pakistan (boilerhouse retrofit).

Strategis Web Site

Canada has made information on a wide range of Canadian technologies easily accessible by launching, in 1996, Strategis, an Internet-based technology solutions provider (http://strategis.ic.gc.ca). Canadian companies, including those in the environment, transportation, and petroleum and oil and gas industries, are part of this large database, which facilitates the transfer of Canadian technologies to developing countries and countries with economies in transition. Canadian Environmental Solutions (CES) is an innovative tool available on Strategis. CES is designed to provide an instant response to specific environmental problems or situations encountered by all sectors of the economy in both domestic and international markets. With its compendium of Canadian solutions to global environmental problems, this comprehensive program promotes Canadian technologies and services that can provide solutions to climate change problems worldwide.

Partners for Climate Protection (PCP)

The Partners for Climate Protection (PCP) program is a partnership between the Federation of Canadian Municipalities (FCM) and the International Council for Local Environmental Initiatives. Supported by the Government of Canada, this initiative helps municipal governments reduce GHG emissions. The central focuses of PCP are engagement, capacity building, and the Sustainable Community Awards Program, which awards innovative approaches to sustainable community development. The FCM was given the United Nations Centre for Human Settlement Habitat Scroll of Honour Award in 1997 for "mobilizing elected officials and staff from Canadian municipalities for the development of local communities and for providing support to sister municipalities in developing countries."

Memoranda of Understanding (MOUs)

Canada has signed MOUs with several countries on issues relevant to climate change. These arrangements promote information exchange, bilateral cooperation, and technology transfer. Three examples of these arrangements are noted below.

The Chinese Meteorological Administration and the Meteorological Service of Canada renewed, in 1996, a five-year MOU on Cooperation in Meteorological Matters. They agreed to further engage China in climate change issues, build institutional capacity, exchange experts, provide training and technology, and assist in modernizing China's weather service.

The Government of Canada and the Government of Brazil signed an MOU on Environmental and Sustainable Development Consultations and Cooperation for the period 1996–2001. The understanding is for the two governments to exchange views on international and regional environmental policy, to cooperate on issues including climate change, and to optimize opportunities to transfer environmental technologies.

In 1999, a Letter of Understanding on Environmental Cooperation between Canada (Industry Canada, Environment Canada) and Egypt was signed to promote environmental cooperation, sustainable development, and the transfer of environmental technologies.

SUMMARY AND CONCLUSIONS

In fulfilment of its obligations under Article 4 of the FCCC, Canada has contributed substantial financial resources and assistance toward capacity building and the transfer of climate-friendly technologies to a wide range of countries. Canada is also increasing its ongoing assistance through a $100 million fund, the recently established Canada Climate Change Development Fund, which is dedicated to helping developing countries combat climate change and simultaneously contribute to sustainable development and poverty reduction.

CHAPTER 8 Research and Systematic Observation of Climate Change

SCIENCE, IMPACTS, AND ADAPTATION

One of the keys to addressing climate change is improving our understanding of the climate system and how natural and human systems interact with it. With this knowledge, we will be better positioned to make choices regarding the rate and magnitude of future emissions reductions and the strategies for adapting to the impacts of climate change.

Since the preparation of Canada's Second National Report on Climate Change in 1997, several significant activities have taken place relating to climate system science, impacts, and adaptation. These activities have helped frame the broad direction and supported a significant portion of the new research that has taken place.

The Government of Canada established the Climate Change Action Fund (CCAF) in 1998 and allocated $15 million over three years to the science, impacts, and adaptation (SIA) component. The overall goals of the SIA component, as articulated in the SIA Business Plan of July 1998, were to:

- reduce the uncertainties in our knowledge of the magnitude, rate, and regional distribution of changes, in order to better estimate the risks associated with climate change and to provide advice on appropriate options to address these risks; and
- determine the impact of these changes upon Canadians' health, safety, environment, economy, and social fabric.

Over the first three years, the SIA component has had two main streams of activity:

- climate system science, focusing on
  - systematic climate monitoring to detect climate change, as well as improve and validate our climate models;
  - key climate processes (including those related to greenhouse gas [GHG] sources and sinks); and
  - regional-scale climate modelling to assess impact and adaptation needs; and
- impacts and adaptation, focusing on
  - the study of the impacts of climate change on Canada; and
  - the development, assessment, and implementation of adaptation responses.

During the first phase of the CCAF, Canada's National Implementation Strategy on Climate Change (NIS) was being developed. Through this process, a number of key initiatives were introduced:

- *The Science, Impacts and Adaptation Options Paper*. This was prepared by the Canadian Climate Program Board (CCPB) and its advisory committees, augmented with membership from provinces and territories, in its role as the SIA Issues Table for the National Climate Change Process (NCCP). The initiative provides a series of recommendations on research needs in SIA and in communicating the climate change issue to Canadians.
- *Canada's First National Climate Change Business Plan (FNBP)*. Within the framework of the NIS, the FNBP is composed of over 300 measures, organized around five main Phase One themes. Many of the measures are based on the options put forward by the above-mentioned Issue Tables/Working Groups in their Options Reports. One of the themes, "Investing in Knowledge and Building the Foundation," includes measures specific to climate system science, impacts, and adaptation.
- *The Government of Canada Action Plan 2000 on Climate Change*. This initiative includes a number of federal measures to address climate change and was the basis for the federal government's contribution to the FNBP. Among the measures contained in the plan are several relating to:
  - climate monitoring — to fill critical gaps in our national network, particularly in the north;
  - sinks — to enhance understanding of the potential of forests and agricultural soils to store carbon; and

- impacts and adaptation — to link researchers to further assess the impacts of and adaptation to climate change in all regions of Canada, and to develop strategies to help Canadians in various sectors adapt to a changing climate.

The measures in Action Plan 2000 build on the $60 million provided in Budget 2000 to establish the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) and on the foundation laid by the first phase of the CCAF.

The first part of this chapter provides an overview of national activities in climate science, impacts, and adaptation in the following areas:

- Climate science
  - climate monitoring
  - climate analysis
  - climate processes
  - climate system modelling
  - climate scenarios
  - climate science assessment
- Climate impacts and adaptation research
- Science impacts and adaptation funding and coordination mechanisms
- Research on socio-economic impacts of response options
- Research on adaptation technologies

Climate science is varied, and often an initiative will span one or two of the subsection headings. In those cases, the authors have made a judgement of what activity fits under which heading.

The second part of this chapter deals with research and development (R&D) activities in the mitigation of climate change.

The focus of the report will be on initiatives implemented since the release of Canada's Second National Report on Climate Change.

Climate Science

Climate Monitoring

Climate monitoring is concerned with determining the past and current state of the climate from the geological record and systematic observations of the Earth's climate. It is only through description of the mean state and natural variability of current climate that it is possible to determine any human-induced climate change.

Monitoring of the climate system covers five components: atmosphere, oceans, hydrology, terrestrial, and cryosphere (ice, snow, and glaciers). Systematic observations have been essential and continue to be needed in order to understand natural climate variability and its causes, monitor the effectiveness of emissions reduction measures, provide Canadians with information on the state of the climate, and improve and validate climate models.

Canada is a vast country involving a large range of climate regimes and ecosystem types, many of which are in inhospitable locations remote from populated areas. Where circumstances dictate, Canada has used remote sensing and complementary technologies to ensure that systematic observations are collected.

Canadian atmospheric monitoring programs reflect a balance between affordability, practicality, and ability to respond to needs on a variety of scales. Consequently, climate observing networks are most concentrated where population and economic activity are the greatest. Nevertheless, they are currently well below internationally recommended standards in the northern two-thirds of the country.

Canada continues to maintain a national network of climate observing stations (many of which are operated on a volunteer or cooperative basis) and a comprehensive climate data management system to provide timely access to quality data. To address Canada's Global Climate Observing System (GCOS) obligations under the United Nations Framework Convention on Climate Change (UNFCCC), a national workshop funded under the CCAF was held in 1999 to develop the elements of a national GCOS plan. A draft of the National GCOS Plan was completed in 1999.

Notwithstanding the above, climate system data are collected by various federal, provincial, and territorial governments and the private sector in an often uncoordinated fashion. Collection is frequently a part of a primary responsibility and not undertaken with the intent of making systematic observations of the climate system. For example, many agencies may be collecting climate data with little consideration of the historical importance of these data. The variety of institutional players, the manner of collection, the state of data management, and the need to consider this national activity as a commitment to the Kyoto Protocol have elevated concerns over data quality and continuity.

The current draft of the National GCOS Plan has been structured to:

- address the challenges of GCOS by:
  - identifying the implications for Canada of the internationally determined requirements for GCOS;
  - assessing Canada's capacity to meet them; and
  - proposing cost-effective options for fulfilling them;

- recognize that there are ongoing domestic requirements for understanding the Canadian climate and its likely response to global climate change processes. This recognition imposes additional requirements on the Canadian climate observing system. The plan attempts to link these domestic requirements with international ones and propose efficient and effective measures to satisfy both; and

- consider the climate observing system as a single system with contributions from the atmospheric, oceanic, hydrologic, cryospheric, and terrestrial domains. The plan attempts to set out how many of the cross-cutting issues that naturally arise might be resolved in an efficient and cost-effective manner — through following international standards, setting national priorities and standards, and strengthening existing national coordinating mechanisms or setting up new ones where needed.

As noted above, the climate science program in Action Plan 2000 addresses two measures that the FNBP under the NIS has identified as requiring urgent priority attention: climate monitoring — to fill critical gaps in our national network, particularly in the north; and sinks, — to enhance our understanding of the potential of forests and agricultural soils to store carbon. The measure under climate monitoring will fill some of the gaps identified in the SIA Options Paper on atmospheric, oceanographic, and cryospheric (snow, ice, permafrost, and glaciers) networks in Canada. The measure will be implemented by federal departments in partnership with Canadian universities and provincial and territorial agencies. Also, to engage the broader community in a more coordinated effort on climate observations, Environment Canada is leading the development of a National Association on Systematic Observations of the Climate; to this end, a meeting involving federal, provincial, and territorial interests was held in January 2001.

The specifics of Canada's national climate monitoring activities can be found in a separate report that has been prepared concurrently. This report, Canada's Contribution to the Global Climate Observing Systems, is being prepared in response to the official Subsidiary Body for Scientific and Technological Advice guidelines recommended by the GCOS program. It provides details of Canada's program of systematic observations of the climate system in the component domains listed above.

Climate Analysis

Climate analysis involves the study of climate data over a variety of time and space scales in order to determine climate trends and variability (including extremes). The work is critical to the issue of climate change detection and to the development of climate change policy, particularly in the federal government.

Research is conducted primarily in federal departments and universities, with limited analysis undertaken by provincial agencies and the private sector.

Canadian air temperature and precipitation trends have been analyzed recently (Zhang *et al.*, 2000) using updated and adjusted station data. The climate analysis revealed that while there have been increases in temperature and precipitation in this century, the extent of variability of precipitation remains within the bounds of an average climate regime. There is

evidence suggesting a degree of agreement between observed trends and those predicted by global circulation models that incorporate an increase in atmospheric gases (Skinner and Whitewood, in press).

There are other examples of Canada's ongoing commitment to climate analysis research:

- The Climate Monitoring and Data Interpretation Program monitors and analyzes Canadian and global climate using integrated historical and proxy data sets to extend the climate record back 1 000–2 000 years. The program also funds the operation of a permafrost and active layer monitoring network, supporting the detection and monitoring of climate change in the Arctic. In Environment Canada, climate data are available from the national archives, subject only to the incremental costs of providing data access to the user. General pricing schedules to reflect the principle of incremental effort are being developed for implementation soon. Steps are also being taken to provide basic access at no charge via the Internet. Fisheries and Oceans Canada, as a direct consequence of its involvement in the program, has adopted a departmental data policy that gives greater recognition and access to data, recognizes that databases are capital assets, and undertakes a multiyear project to inventory all data sets and convert them to managed databases. Other program funding is directed to enhancing climate databases as part of monitoring programs, which include sea level monitoring and Atlantic zone ocean monitoring. Plans are being developed for Arctic and Pacific monitoring.

- The Paleo-Reconstruction of Climate Program is compiling a wide variety of data documenting past environmental conditions (including vegetation, terrestrial and marine fauna, lake levels, and wind) that are utilized to reconstruct climate conditions over the past 20 000 years. Such data, which will be Web-enabled as both maps and databases, are critical to establishing the range and character of natural climate variability and can also provide analogues for assessing the impacts of future climate changes. For example, marine fossil data indicate two lengthy intervals, roughly 4 000 and 9 000 years ago, when the present sea ice barrier of the Northwest Passage disappeared in most summers. During the most recent of these intervals, summer temperatures were less than 4°C warmer than at present, suggesting that the Northwest Passage could become a viable marine transportation route in future decades.

Examples of funded climate analysis initiatives include the following:

- The Natural Resources Canada (NRCan) and Environment Canada lead project, State of the Arctic Cryosphere During the Extreme Warming of 1988: Documenting Cryospheric Variability in the Canadian Arctic and Assessing the Significance of Recent Warming, is synthesizing available information on the state of the cryosphere in the high Arctic, Beaufort Sea, and Mackenzie Delta areas during the extremely warm summer of 1998. It is seeking to determine the significance of the warming response on the basis of the observed variability over the last 30–40 years, the warm decade of the 1990s, and other extremely warm years (e.g., 1960, 1962, and 1988). Major achievements of the study are its documentation of the response and behaviour of ice plugs on the sea ice regime of the Queen Elizabeth Islands and its findings regarding the role of warm years in preconditioning the future response of some components of the cryosphere (e.g., lowered albedo of glacier ice).

- Another project, led by NRCan and ASL Environmental Sciences Inc. and entitled High Arctic Permafrost Temperature Observatories for the Detection of Climate Change: Assessment of Existing Knowledge and Future Monitoring Capability, has been undertaken to ensure that two important permafrost temperature–climate change monitoring networks in the High Arctic are rejuvenated to ensure future long-term monitoring capability. Permafrost data have been acquired at the Alert (latitude 82.5°N) network for 22 years. This is the northernmost permafrost temperature-monitoring site in the circumpolar north. In 2000, automatic data loggers and air temperature sensors were installed. A backlog of earlier data was processed and quality controlled.

- A third project, Prairie Droughts and Surface Winds from Eolian Deposits, is being carried out by NRCan in collaboration with Environment Canada, the Saskatchewan Research Council, Mount Allison University, and the University of Guelph. This project is developing spatial and chronologic evidence of droughts and related surface winds on the prairies by physically examining sand dunes and analyzing remotely sensed data. Model outputs from global circulation models indicate that sand dunes in the prairies will likely be more susceptible to drought, due to decreases in available moisture.

Other related initiatives include:

- the Canadian Council of Ministers of the Environment (CCME) Indicators Study of Climate Change. This project, initiated in 2000, will develop preliminary indicators of climate change in Canada and publish them in a public-friendly document in 2002. The initiative is co-chaired by Environment Canada and Saskatchewan Environment and Resource Management; and

- the work of the Prairie Farm Rehabilitation Administration's (PFRA) Prairie Agroclimate Unit. As part of its long-term agro-climate strategy for PFRA, the unit has undertaken a number of activities, including identification of climate trends and their impact on long-range climate forecasts, as well as management of PFRA's ongoing drought-monitoring and drought-reporting activities.

Climate Processes

Climate processes research addresses issues related to how the climate system functions. These issues include the role of clouds, the oceans, sea ice, permafrost, and land surface processes in the climate system, as well as the function of forests, agriculture, wetlands, and oceans in the global carbon cycle. Proper understanding of these and other processes is required to predict future climate with greater certainty and to support our international negotiations. Expertise in this area is concentrated primarily within university and federal government scientific institutions. Some examples follow:

- The Climate Research Network (CRN) is a collaborative research network, established in 1994. The CRN engages the talents of the university community to expand and complement the scientific knowledge and expertise available in the country with respect to climate change and climate variability. It currently has nine nodes or major projects involving more than a dozen universities. Most of these have succeeded in attracting additional funding from other sources, notably the Natural Sciences and Engineering Research Council of Canada (NSERC). Through this network, the skills of both graduate and post-doctoral students are being developed on climate change issues in a way that might not have occurred otherwise. CRN research is concentrated in areas such as climate variability studies, modelling studies dealing with the ocean (global, Arctic, and North Atlantic), land surface processes, clouds and aerosols, lake and ocean ice, stratospheric processes, the carbon cycle, and regional climate. All these areas are crucial for understanding and predicting climate change in Canada.

- Led by the Government of Canada, the Climate Processes and Earth Observation Program conducts research to improve the understanding of energy and water cycles and their component processes, particularly in cold climates. The program is also developing and implementing improved remote sensing and field measurement methodologies and emphasizes the measurement and modelling of land surface processes and the evaluation and application of regional climate and weather models as integrating tools. Key participants include several federal government departments: Environment Canada, Fisheries and Oceans Canada, and NRCan.

The CCAF has supported a number of climate processes research projects. For example:

- A University of Victoria project, Analysis of the Variability of the Arctic Oscillation under Enhanced Greenhouse Effect, is analyzing the changes in the variability of the oscillation, using information from a climate model. The study is looking at the behaviour of the oscillation under different scenarios of GHG concentrations. Results indicate that large-scale atmospheric circulation patterns may change over Canada under enhanced greenhouse forcing. This implies substantial changes in climate in some regions of the country; however, it also suggests that such changes may be predictable in terms of these large-scale circulation patterns.

Under the umbrella of the World Climate Research Programme (WCRP), Canadian scientists have participated in the coordination, planning, and research of at least two of the WCRP initiatives, which have served to increase understanding of climate and atmospheric processes:

- Canadian oceanographers working within the World Ocean Circulation Experiment (WOCE) have provided new insights into how the Atlantic thermohaline circulation has varied over the past five decades. Their work has contributed to an increased understanding of the role of the North Atlantic oscillation in this variability and to the examination of the potential suppression of the Atlantic thermohaline circulation under climate change using coupled global atmosphere–ocean climate models. In addition, in May 1998, Canada sponsored a major international WOCE scientific conference, which reviewed preliminary results from the analysis of the WOCE data sets (1990–1997) and defined the agenda for the analysis and modelling phase of this program (1998–2003).

- As a contribution to the Global Energy and Water Cycle Experiment (GEWEX), the Canadian Mackenzie GEWEX Study (MAGS) continues to study the hydrologic cycle over and within the permafrost-laden and largely snow-covered lands of the Mackenzie River basin in Canada's far north and is answering crucial questions on the freshwater flow into the Arctic Ocean. As well as examining and modelling a host of individual processes in the atmosphere and at the surface, MAGS is studying the collective behaviour of basin-scale phenomena. For example, MAGS has shown that water vapour anomalies (below or above normal) that are imposed from the larger scales are magnified by interacting atmospheric, surface, and hydrologic processes within the basin to produce more extreme discharge variations. The discharge into the Arctic Ocean can be simulated and predicted only if our models properly account for these interactive processes.

Within the International Geosphere Biosphere Program (IGBP), the tradition of scientific collaboration and international coordination continues with involvement in core activities, such as:

- the Joint Global Oceans Flux Study (JGOFS), which seeks to understand GHG flux at the atmosphere–ocean interface and the biological processes of the oceans;

- Past Global Changes (PAGES) and national contributions to this core program, such as Climate System History and Dynamics, which was created to develop a national capability in paleoclimate modelling in which both general circulation and reduced system models of the climate system may be tested against records of past climate change to improve the parameterization schemes on which such models are based; and

- Global Change and Terrestrial Ecosystems (GCTE), which examines the changes in climate, atmospheric composition, and land use, and how these feed back into climate. Canadians have been involved in two of the international Free-Air CO_2 Enrichment (FACE) studies, first in the Great Plains of the United States and more recently in Panama. The latter study is coordinated by McGill University and is the only *in situ* experiment testing the effects of high carbon dioxide (CO_2) on tropical plantations. The first testing of the FACE apparatus/site took place in the spring of 1999.

Canadians have also been involved in the development of NASA's Earth Observing System

Program, which consists of a science component and a data system supporting a coordinated series of earth observation satellites. Two programs where Canada has taken a leadership role are:

- Cryospheric Systems (CRYSYS-EOS), a Canadian-led study currently involving over 30 researchers from 14 universities and five federal institutions. CRYSYS provides a mechanism to mobilize and focus the Canadian scientific community in responding to national and international needs for climate monitoring in data-sparse regions of Canada, for validation of global climate models, and for providing near real-time cryospheric information for operational use (e.g., snow water equivalent, lake ice extent). One of the most significant achievements to date has been the development and validation of satellite-based approaches for mapping snow properties (extent, water equivalent, wet/dry state) in various climatic regions and landscapes of Canada and the transfer of the research into operational products such as runoff predictions; and

- Measurement of Pollution in the Troposphere (MOPITT), a Canadian instrument for measuring tropospheric carbon monoxide and methane. MOPITT was launched in December 1999 aboard the EOS Terra satellites.

The International North Water Polynya Study (NOW) is part of the International Arctic Polynya Programme of the Arctic Ocean Sciences Board. The NOW research program represents a concerted effort to understand the functioning and importance of the North Water ecosystem, a region located in northern Baffin Bay. In addition to investigating the polynya as a model for the potential response of the Arctic Ocean to a climate-induced reduction of sea ice cover, NOW is considering the impact of climate variability on the dynamics of the North Water. Early syntheses of results obtained in the North Water suggest that reduction of ice cover duration over the Arctic shelves would tremendously increase biological productivity and carbon fluxes; however, it could also set the stage for the replacement of the unique Arctic fauna by temperate communities.

Canada is a party to and a member of the scientific steering committee for the Inter-America Institute for Global Change Research (IAI), an intergovernmental organization supported by 18 countries in the Americas dedicated to fostering increased understanding of global change phenomena and their socio-economic consequences in the Americas. Its primary objective is to encourage research beyond the scope of national programs by advancing comparative and focused studies based on scientific issues important to the region as a whole. Two IAI research projects, one dealing with climate variability in the Americas and another with biogeochemical cycles under land use, are led by Canadians.

GHG Sources and Sinks

Research into biological GHG sources and sinks is aimed at questions such as how GHG sources and sinks function under different climate conditions. Canada has initiated the development of a national strategy for carbon sequestration research to help focus research on this important component of the climate system. Currently, there is a wide range of efforts at both the federal and provincial levels.

The federally funded work uses in-house resources and is complemented by funds from the Program of Energy Research and Development (PERD) and the CCAF. It includes the following activities:

- *Agriculture and Agri-Food Canada*: modelling and flux studies to evaluate the development of management practices to reduce GHG emissions and increase the sink potential of agricultural soils, as well as funding support to universities. The Climate Change Funding Initiative (CCFI), in conjunction with the Canadian Agri-Food Research Council (CARC), provides part of the funding.

- *Environment Canada*: monitoring programs, flux studies, infrastructure support for the Boreal Ecosystem Research and Monitoring Study (BERMS) project, studies related to land surface processes, and aquatic ecosystem studies.

- *Fisheries and Oceans Canada*: air/sea exchange, carbon dioxide transport and sequestration, carbon transformation and losses from the surface ocean, numerical modelling studies, and biological uptake and removal to the deep ocean through convection studies.

- *NRCan*: estimates of carbon stocks and changes in stocks for Canada's managed and total forests, projected effects of climate change on natural disturbance regimes in Canada's forests, projected changes in forest ecosystems as a result of climate change, integrated assessment of forest response to atmospheric chemistry, projected carbon stocks and changes in carbon stocks under the influence of climate change and natural variability regimes in Canada's forests, coal bed methane studies, and estimation of components of the forest and terrestrial surfaces through remote sensing.

- *BIOCAP*: (Biosphere Implications of CO_2 Policy in Canada) Canada Foundation is a national not-for-profit, university-based research organization that seeks to provide a strategic focus for multidisciplinary scientific and technical teams investigating how our forests and farmlands can be harnessed to help meet Canada's climate change objectives and to contribute to a dynamic and sustainable bio-based economy. Working with other private and public sector partners from across Canada, BIOCAP is responding to Canadian research priorities by coordinating a series of national university-based research networks that will collaborate to find meaningful answers to the pressing scientific questions surrounding biosphere GHG management. In 2000, BIOCAP invested over $1 million of federal granting council as well as provincial and industry seed funds into this effort and is working to build its funding base.

Examples of research into biological GHG sources and sinks at the provincial level follow:

British Columbia

- The provincial government is conducting research to develop a policy for the accounting of agricultural soil sinks. Alternative cropping practices will be identified for areas where there is potential to increase soil organic matter.

Alberta

- The Alberta Agricultural Research Institute funds a variety of agricultural research programs, a number of which may have GHG benefits.

- Alberta Agriculture, Food and Rural Development is one of a number of partners supporting a multiyear research study to better understand soil carbon dynamics. The purpose of the study is to develop scientifically sound methods to assess changes in soil carbon based on management practices.

- The Government of Alberta funds the Foothills Model Forest and the Sustainable Forest Management Network; a portion of the funding supports research into the carbon dynamics of forests and other landscapes of the boreal forest.

The CCAF has also supported a number of projects that seek to increase our understanding of the behaviour of GHGs:

- Led by NRCan in collaboration with the Canadian Forestry Service, the University of New Brunswick, Forest Protection Ltd., Ontario Forest Research Institute, Alberta Lands and Forest, and Daishowa-Marubeni Inc., the project Climate Change Effects on Insect Outbreaks and Management Opportunities for Carbon Sequestration is seeking to improve our understanding of how insect infestation will affect Canadian forests under climate change. Using historical and current information in a modified pest control model, the researchers hope to create scenarios on the carbon storage potential of Canadian forests, to predict the extent and impact of future outbreaks, and to fine-tune forest management practices as a tool against insect outbreaks.

- Led by Fisheries and Oceans Canada in collaboration with Manitoba Hydro, Hydro-Québec, the University of Alberta, CRESTech, Environment Canada, and the Canadian Foundation for Innovation, the project Reservoirs: An Important Source of Greenhouse Gases in Canada is a continuation of the 1998 FLUDEX (Flooded Uplands Dynamic Experiment). In this

experiment, the research team created three small reservoirs to monitor the decay of plants and the emissions of GHGs.

- Led by Agriculture and Agri-Food Canada in collaboration with the National Research Council (NRC) and several universities, the project Sharpening the Regional Picture of Nitrous Oxide Emissions from Agricultural Lands has improved the algorithms for estimating nitrous oxide emissions by incorporating the latest research on soil processes and validating the estimates with the newly developed aircraft-based flux measuring technique. The research results are being used to update the Intergovernmental Panel on Climate Change (IPCC) 1990 estimates on nitrous oxide emissions from agricultural lands, which are highly uncertain. In the cases examined, the aircraft-based flux measurements for nitrous oxide are in fairly good agreement with the revised IPCC estimates, ranging from 0 over forest to about 100 ng/m^2 per second over an intensively cultivated region in the spring.

- Led by Agriculture and Agri-Food Canada in collaboration with Alberta Agriculture, Food and Rural Development, the project Assessing Nitrous Oxide Tradeoffs to Carbon Sequestering Management Practices will link various research projects in agricultural regions in Canada that are considering the issue of nitrous oxide/carbon dioxide tradeoffs. The integrated study will facilitate the development of joint models that will permit researchers to better estimate the behaviour of carbon dioxide and nitrous oxide emissions on a regional and national basis. Ultimately, this will result in recommendations for optimum soil management practices that allow for the GHG emissions tradeoff.

Climate System Modelling

Climate prediction (modelling) focuses on the response of the climate to the effects of increased concentrations of GHGs and other influences on the climate system. Predictions of the probable rate and regional variations of climate change can be provided only through the development of credible global and regional climate models, requiring regional, national, and global climate data sets, and the results of climate process research.

- The Climate Modelling and Analysis Program at Environment Canada develops and uses sophisticated atmospheric and coupled climate models and advanced analysis of observed data and model output to improve understanding of present, past, and future climates. The models and analysis tools are used in short-term climate forecasting for studies of climate predictability and variability and to project and analyze the future climate change that will result from the anthropogenic changes in the composition of the atmosphere. Canada, through Environment Canada's Canadian Centre for Climate modelling and analysis (CCCma), has developed a third-generation global climate model that is considered to be one of the top four such models in the world. The United States used results from the Canadian model for its national climate impacts assessment. Also, a group at the Université du Québec à Montréal has developed a regional climate model that has been run for western North America and is preparing to do a similar run for the eastern part of the continent.

- Canadians have contributed to the understanding of climate modelling through the modelling components of those initiatives noted under "Climate Processes" above and through their involvement in the international Joint Scientific Committee/Climate Variability and Predictability Project Working Group on Coupled Modeling (WGCM), which oversees the development of fully coupled atmosphere/ocean/land/cryosphere models to study climate variations over a number of time scales. Canadians have also contributed to the World Meteorological Organization Commission on Atmospheric Sciences/Joint Scientific Committee Working Group on Numerical Experimentation (WGNE), which is developing and refining atmospheric models for use in weather prediction and climate studies.

The following projects are examples of CCAF-supported initiatives:

- Led by Fisheries and Oceans Canada in collaboration with Environment Canada,

Memorial University, and the Université du Québec à Rimouski, the project Northern Oceans Dimethylsulphide Emission Models is increasing our understanding of the relationship between dimethylsulphide (DMS) emissions from microalgae and climate change. The study focused on determining the key mechanisms responsible for DMS, developing models for production and emission, and estimating biogenic sulphur exchanges for climate models.

- Led by Environment Canada, the project Scaling of Cold Season Land Surface Processes and Its Application to Improving Land Surface Parameterizations in Canadian Climate Models is improving Canadian land surface representation in climate models through a modelling study involving simulations of different regions and seasons. This work will improve the capability of Canadian climate models to predict cold season conditions over Canada in climate change scenarios.

Climate Scenarios

Research on the potential impacts of climate change and on subsequent options for adaptation requires scenarios of possible future climates, developed for the appropriate time and space scales and the relevant variables for the natural ecosystem or socio-economic sector under study. These scenarios can be derived from outputs of climate models, or they may be developed based on analysis of the response of systems to past and/or current climates. The development of climate impact scenarios is a very new and important field.

With the support of the CCAF, a national workshop was held to help identify the climate scenarios that would meet the needs of the climate impacts research community in Canada. This work involves a partnership between researchers working on climate models and those working on the impacts of climate change.

In addition, with the support of the CCAF, a national Scenarios Facility has been created to supply these scenarios to climate change impact researchers. The facility has links to similar international activities in the United States and Britain, so that information and advice are available. Partners in the Scenarios Facility include the Canadian Institute for Climate Studies (CICS) in Victoria, British Columbia, Environment Canada, and the CCAF.

In terms of scenario research, more work is needed on sophisticated interpolation techniques capable of incorporating topographic effects to produce, for example, high-resolution climatological fields from the low-resolution long-term observing station network, and on downscaling the outputs from climate models into a form that can be used by impacts researchers. There is also a need for modern climate data sets, including frequency analysis of extreme events, and paleo-environmental reconstruction for recent-past climates to guide or inform discussions of the potential range of impacts. Some of the gaps are being addressed by CCAF-funded projects, but more remains to be done.

The CCAF-funded research on scenarios includes the following initiatives:

- Led by Fisheries and Oceans Canada in collaboration with Environment Canada and the University of British Columbia, the project Climate Change Scenarios and Sockeye and Coho Salmon Stocks has developed climate scenarios for two species of salmon (sockeye and coho) from two river basins (the Fraser and Nass) for fresh water, open ocean, and coastal ocean. Scenarios will be compared with historical data and used with existing models of salmon growth and mortality to assess possible impacts. The study will investigate the possibilities and difficulties of applying climate change scenarios and develop the expertise and experience needed for future detailed assessments.

- Led by NRCan in collaboration with the Université du Québec à Montréal, the Saskatchewan Research Council, and Environment Canada, the project High Resolution Assessment of Impacts on Canada's Forest Ecosystem is assisting ecosystem impact researchers by providing spatially detailed climate scenarios covering the regions where forests may establish in the future, as well as those that are forested today.

Climate Science Assessment

Canadians have made significant contributions to the work of the IPCC; roughly 30 scientists

from government, universities, and the private sector have participated in the preparation of the Third Assessment and related Special Reports. Several Canadians were involved in the Third Assessment as convening lead authors or lead authors. A Canadian is also a member of the Bureau for IPCC Working Group One. Funding support for many of these contributors has been provided by the CCAF. In addition to the IPCC activity, there is ongoing work in federal departments, such as in the Science Assessment and Integration Branch of Environment Canada.

Climate Impacts and Adaptation Research

Climate impacts and adaptation research is aimed at improving the understanding of Canada's vulnerability to present and future physical, ecological, socio-economic, and health impacts from climate change. Once a better appreciation of that vulnerability exists, steps can be taken to develop effective strategies to adapt. This research takes place in many agencies across the country, including federal and provincial departments, academic institutions, and the private sector, and is supported to a significant degree by the CCAF under the aegis of NRCan. Much of the work takes place through individual research projects, although some work is also being done collaboratively with stakeholders in case studies. To date, more of the emphasis has been on examining the impacts than on adaptation, and the greatest attention has been paid to physically based systems: agriculture, water resources, forests, landscapes, and ecosystems.

In 1998, the Government of Canada established the CCAF to investigate options for reducing GHG emissions, encourage climate change action by individual Canadians through national awareness and community projects, fund practical and visible demonstrations of climate change mitigation technology, and engage scientists and stakeholders in the science, impacts, and adaptation aspects of climate change. Using the results of the Canada Country Study completed in 1998 (see Chapter 6) as a starting point, the impacts and adaptation component of the CCAF identified research, knowledge, and capacity gaps on a regional and sectoral basis and has targeted research accordingly.

Between 1998 and 2001, the impacts and adaptation component of the CCAF funded over 75 projects (investigating potential impacts and adaptations within several natural and human systems) and workshops (facilitating discussion among experts on regional and sectoral priorities). The projects funded encompass several economic and social sectors, including agriculture, forestry, human health, fisheries, water resources, coastal zones, terrestrial ecosystems, infrastructure, recreation and tourism, communities, and issues that cross sectoral and geographic boundaries. Principal investigators include scientists affiliated with the federal government, universities, the private sector, and non-governmental organizations (NGOs). Projects also span the country, with research occurring in each province and territory.

The CCAF program requires that projects lever financial and in-kind support from other partners to approximately 50% of the total project budget. As a result of this requirement, the program has been able to achieve higher levels of productivity and build research capacity in the areas of climate change impacts and adaptation than would otherwise have occurred.

In addition to these research projects, the CCAF has produced and contributed to several outreach products specifically addressing the impacts of climate change in Canada. These products include a series of posters on the regional impacts of climate change aimed at the high school level and general public, and a publication, Sensitivities to Climate Change in Canada, that contains a series of maps indicating the landscapes and natural resources most sensitive to climate change.

The Canadian Climate Impacts and Adaptation Research Network (C-CIARN) is a federal government initiative, in partnership with provincial and territorial counterparts, to encourage the sharing of knowledge regarding impacts and adaptation research. When complete, the network will consist of six regional and seven sectoral nodes. Each node will facilitate access to data and information in this area of research and contact between individuals or interest groups pursuing similar lines of investigation. As of March 2001, three regional nodes had been established.

Environment Canada's Adaptation and Impacts Research Group promotes and conducts research designed to increase Canadians' understanding of atmospheric change impacts and the required adaptations. These research activities are designed to provide Canadians with information on the environmental, social, and economic risks and impacts caused by vulnerabilities to atmospheric change, variability, and extremes, and on the viability of adaptive responses. The program focuses on a number of key research themes (e.g., integrated assessments, health and atmospheric change, human dimensions of weather and climate, water and climate variability and change, integrated air issues, adaptation and impacts science) and works in partnership with selected universities and Canadian and international collaborators.

Adapting to Climate Change Impacts on the Landscape is a combined government, university, and industry effort coordinated by NRCan. It is assessing how climate change could affect selected aspects of the Canadian landscape in order to help decision makers determine their adaptation options. This initiative is building on previous collaborative research projects, led by NRCan and Environment Canada, for the High Arctic, the Mackenzie basin (western Arctic), the Palliser Triangle of the Prairies, and the Great Lakes–St. Lawrence basin. Current topics include sea level rise impacts on the coasts of the western Arctic and Prince Edward Island, landslides in the Rocky Mountains, slope stability implications for pipelines across Canada, drought frequency on the Prairies, permafrost thaw and impacts on infrastructure in the Northwest Territories, and flooding in the Red River basin.

The Federation of Canadian Municipalities and NRCan have partnered in a pilot project investigating the risks to infrastructure in several municipalities across the country, including Charlottetown, Prince Edward Island; Lachine, Quebec; Hinton, Alberta; and Norman Wells, Northwest Territories.

The Ecosystem Initiatives, led by Environment Canada and involving other federal departments, provincial/territorial and municipal governments, universities, and community organizations, include the impacts of climate change in their consideration of economic and social impacts on the long-term quality of ecosystems. The Great Lakes, the St. Lawrence River, British Columbia's Georgia Basin, the Atlantic coast, and northern rivers are among the ecosystems currently being studied.

The Government of Saskatchewan is studying the vulnerability of the western Canadian boreal forest to climate change. This project will assess vulnerability in terms of insect or disease outbreaks, frequency and intensity of forest fires, and impacts of moisture stress. The focus will be on working with the forestry industry to identify these impacts at the ecodistrict level in ways that are relevant to forestry operations and planning horizons. Funding is provided by the impacts and adaptation component of the CCAF.

In the Yukon, the recently created Northern Climate ExChange serves as a northern entry point into the study of climate change in the circumpolar north. It conducts research and education on the impacts of, and adaptations to, climate change in the north; supports the development of resource-efficient technologies and practices that can help mitigate climate change impacts; and facilitates the exchange of scientific, traditional, and local knowledge, technology, and expertise via a circumpolar "trade route."

The climate change strategy of Quebec includes measures to develop and apply regional climate and water models and other analytical tools to predict climate change and its consequences and to comprehensively document the impacts of climate change on the population, ecosystems, and different sectors of activity.

British Columbia is engaged in a project to research climate change impacts on fish and fish habitat, establish gene banks to protect the diversity of fish populations affected by climate change, cooperate with other agencies to restore fish habitat, adopt technology and techniques for selective fisheries, develop and diversify new fisheries, and communicate with professionals and the public.

Science Impacts and Adaptation Funding and Coordination Mechanisms

As stated in the introduction to this chapter, the CCAF was launched in 1998 with funding of $15 million over three years for SIA activities. This component is co-managed by Environment Canada (responsible for the climate science) and NRCan (responsible for impacts and adaptation); it

also involves several other federal departments in program management and decision making. The work programs for the CCAF-SIA were developed through a series of national workshops that formed the basis for several open and targeted calls for proposals. Proposals are required to address key gaps, demonstrate partnerships, and aim to lever 50% of resources from other sources. All research proposals are subject to independent scientific peer review. In Budget 2000, the federal government announced that the CCAF would be continued for an additional three years to March 2004 and would include an SIA component.

The climate science component has focused on several key areas identified through a national consultation process: climate model improvements, GHG sources and sinks, climate monitoring, Arctic climate system research and monitoring, climate change scenarios, and climate and weather extremes. Scientists from federal and provincial governments, universities, and the private sector have all participated in this program. Some 79 projects on climate system science have been funded, many of which have been detailed in this document in the appropriate section.

The impacts and adaptation component provides funding for targeted research to better understand the impacts of climate change on the regions and sectors of Canada, and how we can adapt to these impacts. This funding is distributed through an open, competitive process where proponents apply for funding and are peer-reviewed by experts within and external to the federal government. The CCAF supported over 75 impacts and adaptation projects in a variety of economic sectors and all regions of the country. The projects began reporting results in April 2001.

In October 2000, the federal government announced its Action Plan 2000 on Climate Change. Among the many measures included were those to increase funding for research on biological sinks and impacts and adaptation.

Budget 2000 provided a one-time grant of $60 million for the establishment of the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS). The CFCAS was incorporated as a not-for-profit corporation at arm's length from government and is associated with the Canadian Meteorological and Oceanographic Society. The primary purpose is to fund research and modelling in the climate system and atmospheric sciences, including extreme weather and air quality, in order to strengthen Canada's scientific capacity; improve scientific understanding of processes and predictions; provide relevant science to policy makers; improve understanding of the implications of these sciences for human health and for the natural environment; foster collaboration and interdisciplinary approaches; and encourage the participation and support of others, including the private sector.

Eligible research projects include scientific studies that address one or more of the following areas:

- understanding key climate system processes, including GHG sources and sinks;
- understanding key meteorological and atmospheric processes that impact on air quality;
- improving knowledge of oceanic and atmospheric processes leading to improved marine environmental predictions;
- understanding the probability of occurrence and/or improving the prediction of extreme and hazardous weather; and
- developing and improving weather, air quality, and climate system models for Canada.

Eligible recipients are individual researchers and/or collaborative networks of researchers who are affiliated with Canadian universities, other degree-granting institutions, or not-for-profit organizations federated or associated with Canadian universities.

The CFCAS issued its first call for proposals and letters of interest in the summer of 2000 and in February 2001 announced initial funding awards of approximately $2.2 million over three years in the areas of climate, GHGs, and extreme weather.

NSERC is the national instrument for making strategic investments in Canada's capability in science and technology. NSERC supports both basic university research through research grants and project research through university–industry partnerships, as well as the advanced training of

highly qualified people in both areas. NSERC's role is to make investments in people, discovery, and innovation for the benefit of all Canadians. It supports more than 9 000 students in their advanced studies, funds 8 700 researchers, and engages 1 000 private sector partners. Although climate change is not identified as a priority funding area for NSERC, NSERC does support significant basic climate change process, modelling, and impacts research to the tune of approximately $10 million a year.

The Canadian Climate Program Board (CCPB), created in 1979, is a coordinated effort to comprehend global climate as it relates to Canada and its adjacent oceans. It represents the total of the collaborative work of agencies, institutions, and individuals in Canada concerned with climate system SIA. Its members include representatives from federal departments, the provinces and territories, universities, NGOs, and the private sector. The CCPB has three advisory committees, one on climate system science, one on impacts and adaptation, and one on outreach. The CCPB participated in the NCCP, developing a Foundation Paper and an Options Paper on SIA in 1999.

In 1995, a Natural Resource Departments Memorandum of Understanding (MOU) Working Group composed of the departments of Agriculture and Agri-Food, Fisheries and Oceans, Environment, and NRCan established an MOU on Science and Technology (S&T) for Sustainable Development. In 1998, the MOU was renewed, and a fifth member, Health Canada, joined the Working Group. Several sub-working groups were established, including one dealing with climate change and variability. The Climate Change and Variability Working Group has convened or sponsored several workshops and authored statements on the science of climate change and its impacts. It has also served as one of several useful mechanisms in facilitating collaboration among departments with different interests, skills, and outlooks. In 1999, a new sub-working group on ecosystem effects was formed.

PERD is an NRCan program that supports and complements the energy R&D activities of 11 federal departments and agencies. PERD has recently restructured its program. In terms of climate SIA, there are two key strategic objectives of the new program: S&T to support the Canadian energy sector's response to the impacts of climate change, and S&T to enhance the natural uptake of GHGs from the atmosphere. PERD funding, at about $4 million per year, is critical in supporting ongoing research in federal departments.

Research on Socio-Economic Impacts of Response Options

Several studies on the cost impacts of climate change on selected regions and sectors are under way. The overall goal in funding this suite of projects is to help identify the most suitable methodologies for a national study of the costs of impacts and adaptation.

Research on Adaptation Technologies

Research on adaptation technologies is in its infancy. The CCAF has funded two projects to develop technologies that will help urban communities adapt to warmer temperatures. One project is investigating the technology of rooftop gardens as a means of reducing the urban heat island effect, and the other has helped to develop a long-term strategy to employ light-coloured building materials and afforestation to reduce urban heat.

Canada has always had a strong program in the area of climate science. This program has been strengthened with recent initiatives such as the CCAF and Action Plan 2000, which have also served to enhance activities related to impacts and adaptation. These initiatives will help tackle key issues with respect to sinks, help fill gaps in Canada's monitoring networks, particularly in the north, and bolster research on impacts and adaptation. However, much work in all areas, as identified in the SIA Options Paper, still requires attention. Further attention to address these needs will ultimately allow Canada to:

- significantly enhance our scientific capacity across the country to understand and predict the climate and to foresee the impacts on Canadians and our socio-economic and environmental systems;

- prepare Canadians so that their exposure to risks from climate change can be reduced by the development of the adaptive options that minimize economic and social costs, sustain

their well-being, and protect vulnerable ecosystems;

- provide information to Canadians and decision makers so that they may continue to make wise choices regarding future GHG emissions reduction and implement suitable adaptation strategies;

- allow Canadians and their governments to participate knowledgeably, and from a position of scientific credibility, in domestic and international discussions related to climate change actions (e.g., on the the use of sinks);

- make a suitable contribution, as a developed country and in our own self-interest, to our knowledge of the climate, its future evolution, and possible impacts and our vulnerability to them; and

- meet our FCCC and Kyoto commitments on systematic observations, climate research, and impact studies.

RESEARCH AND DEVELOPMENT ON MITIGATION

Canadian investments in technology innovation are a solution to both short- and long-term climate change challenges. The Government of Canada, in partnership with provinces, universities, and industry, has been supporting R&D activities for years, both domestically and internationally, to reduce GHG emissions and mitigate potential climate change impacts. Members of the Climate Change Technology Issues Table (1999a) acknowledged the key role of R&D as follows:

> *Since technology plays a pervasive role throughout the economy, the availability of cost-effective technologies with improved environmental performance is vital to a sustainable future for Canada. Therefore, technology development will be a fundamental element of Canada's national implementation strategy for reducing greenhouse gas emissions.*[44]

Current R&D activities on mitigation target four main objectives: making energy supply and use more efficient, developing alternative energy sources, managing carbon dioxide emitted from large stationary fossil fuel point sources, and enhancing the natural uptake of carbon dioxide from the atmosphere.

The federal government supports technology innovation that addresses climate change issues faced by all sectors of the Canadian economy. Since the First Conference of the Parties (CoP) in 1995, some existing S&T programs have been realigned, and others have been strengthened. New initiatives, including technology development, were announced in Budget 2000. The following sections outline the R&D programs and activities that focus on mitigating GHG emissions.

Transportation Sector

The main objective of R&D in transportation is to reduce energy demand and emissions, including GHGs. Most of the research is directed to light-duty vehicles, focusing on cleaner and alternative fuels, engine hardware technology, engine combustion, exhaust after-treatment systems, fuel storage, refuelling equipment, and the development of fuel cells and electric and hybrid vehicle components and their supporting infrastructures. Research is also under way to optimize the energy efficiency of transportation systems with a focus on urban traffic management and transit systems, intermodal freight efficiency, and air transport.

The Canadian Lightweight Materials Research Initiative (CLiMRI) is an example of a promising research program that will result in GHG reduction. The federal government, in partnership with the provinces, universities, and the private sector, is developing and implementing light-weight and high-strength materials in transportation applications. The main purpose is to reduce GHG emissions through improved vehicle efficiency while improving the competitive performance of the Canadian primary metals, automotive, truck, rail car, and aircraft manufacturing industries and their associated parts suppliers.

44 Technology Issues Table, Enhancing Technology Innovation for Mitigating Greenhouse Gas Emissions, Government of Canada, December 1999.

Significant research is under way on hydrogen and fuel cells, including production of hydrogen from renewable energy sources, fuel cell technologies, and hydrogen storage. Canada is a world leader in the development of fuel cells for vehicles. Buses operating in Vancouver use a hydrogen generation unit built by Stuart Energy Systems that provides hydrogen to fuel cells developed by Ballard Power Systems. Dynatek Industries Ltd. has developed the world's lightest containers for compressed hydrogen.

Industrial Sector

R&D offers several opportunities to reduce the overall energy intensity and associated GHG emissions from this sector while improving productivity. Current research activities focus on energy-intensive processes and environmental issues. Energy-efficient separation, drying, and heat management technologies are being developed for applications in mining operations, metal production, the pulp and paper industry, and the manufacturing sector. Better process integration and advanced controls and sensors will also help reduce GHG emissions. New eco-efficient process technologies that address resource utilization efficiency, emissions, and opportunities to make new value-added products/outputs are also under development.

Several other technologies offer great potential for GHG reduction, both inside and outside the industry sector: *electrotechnologies* use electricity to manufacture or transform raw materials into intermediate or finished products; *catalysts* lower the energy required or increase the production rate of a chemical reaction; *biotechnologies* utilize or mimic aspects of natural ecosystems to replace chemical processes and reduce reliance on fossil fuels; and *advanced materials* offer enhanced physical properties.

NRCan's Industry Energy Research and Development (IERD) Program and NRC's Industrial Research Assistance Program (IRAP) are two examples of federal funding programs that support the development and adoption of innovative industrial technologies.

Hydrocarbon Supply

Until renewable energy sources and alternative feedstock for chemical processes are competitive for mass applications, the world will continue to depend on fossil fuels. However, fossil fuel production and use are a major source of anthropogenic GHGs. Consequently, the main challenge for the hydrocarbon sector is to develop cleaner production and processing technologies.

The demand for natural gas is forecast to increase, because its combustion releases less GHGs than other fossil fuels. Research is under way to develop advanced exploration tools to discover new reserves of natural gas in remote regions of Canada (offshore and northern regions). Production techniques and equipment need to be adapted to severe climate conditions. New sources of natural gas such as coal bed methane are being studied as well. Methane, a powerful GHG, is emitted during natural gas processing and transportation. Natural gas associated with crude oil production is either reinjected or flared. R&D projects are carried out to better control these emissions. For example, the Flaring Research Initiative, managed by Environment Canada, is a coordinated research program to reduce or eliminate the potentially harmful effects of flaring solution gas.

The production of heavy oils and bitumen from oil sands will eventually surpass the production of conventional crude oil. Research aims at developing more efficient technologies to produce and process heavy oils and oil sands that would translate into reduced carbon dioxide emissions. The Canada Centre for Mineral and Energy Technology (CANMET) Western Research Centre in Devon, Alberta, is participating in a joint venture, the National Centre for Upgrading Technology, with the oil sands industry, the Government of Alberta, and universities to meet that objective.

Of note is the growing interest in capturing carbon dioxide from power plants or other sources to enhance oil recovery. The International CO_2 Monitoring Project in Weyburn, Saskatchewan, involves the participation of several partners who wish to better understand the injection process and sequestration of carbon dioxide in geological formations. It is estimated that about 14 million tonnes of carbon dioxide will be held in the ground and 130 million barrels of oil will be recovered over the life of this project. Other carbon dioxide management

initiatives are listed in the section on electricity generation.

Building Sector

It is estimated that energy efficiency could be improved by about 50% through R&D, deployment activities, and best practices. GHG emissions would be proportionally reduced as well. Current R&D focuses on the development of innovative approaches to energy-using equipment and to residential and commercial building design and construction, including the integration of renewable energy technologies for on-site power generation and heating. More specifically, the CANMET Energy Technology Centre in NRCan, NRC, Canada Mortgage and Housing Corporation, Public Works and Government Services Canada, and Health Canada are working closely with the building industry on advanced heating, ventilating, and air conditioning systems; innovative lighting and daylighting technologies; "intelligent" building automation and control equipment; retrofit and reengineering of buildings and housing; and sustainable design and construction of buildings and housing.

Prototypes and new products and techniques can be tested and evaluated at the Canadian Centre for Housing Technology, a unique research facility for the building industry and public research organizations. This centre, located on NRC's campus in Ottawa, consists of two single family R-2000 houses (one is used for testing activities and the other as a "reference" house) and a three-unit row house.

Communities

Communities rely on a number of systems, such as electricity distribution, transportation, water supply, waste management, and communication. These systems, which often intertwine, are seldom planned and built to use resources and energy efficiently and to limit GHG emissions. A better integration of these systems is key to reducing the environmental impacts of communities.

The nature and needs of communities differ from one region to another in Canada. For example, remote communities are not usually connected to power grids and use diesel generators for producing electricity. These communities, particularly in northern regions, are often located in fragile ecosystems.

The overall research objective in this area is to improve the design and integration of systems to decrease overall energy needs and associated environmental impacts. Another objective is to develop and deploy off-grid power generating systems that are more efficient and use lower carbon fuels. Work on co-generation (heat and power), district heating and cooling, use of local renewable energy sources, and planning tools for better community system integration is under way.

RETScreen™, a pre-feasibility analysis model developed by the CANMET Energy Diversification Research Laboratory of NRCan, helps evaluate the cost-effectiveness of renewable energy applications. Off-grid communities, as well as renewable energy developers, in Canada and abroad have used this simple and affordable tool to identify alternative electricity sources and reduce air emissions from conventional fossil fuel–powered systems. By using RETScreen™, preliminary feasibility studies for more than 50 potential projects were conducted at a cost of less than $2 000 each. As a result, several thousand dollars were saved, and that money has been invested in some of the projects that did go ahead.

Electricity Generation

Deregulation is modifying the electricity market in North America. As a result, interest in small-scale electric power generation, such as renewable technologies and microturbines, is growing. Environmental concerns are also a driving factor for adopting new ways of generating electricity, especially those that reduce emissions and can provide both electricity and waste heat for industrial, commercial, and residential buildings.

Improvements achieved through R&D have increased interest in renewable energy technologies. However, technological barriers still need to be overcome in order to increase their competitiveness and accelerate their deployment. The federal government is assisting

renewable energy companies by providing technical and financial support to improve existing technologies and develop new products. Examples include wind turbines suitable for extreme cold climates, more efficient ultra-low-head hydro turbines and control systems for small hydro schemes, performing biomass conversion systems such as pyrolysis, gasification, gas turbines, and boilers, and cost-effective photovoltaic modules and ancillary systems. Canadian expertise in certain renewable energy technologies is also exported to other countries to help reduce their emissions.

R&D is also being carried out on small distributed fossil fuel power generation. The emphasis is on combined heat and power systems, such as microturbines and solid oxide fuel cells.

Coal is a major contributor to electric power generation in the Prairies, Ontario, and the Maritimes. Environmental issues, in particular GHG emissions, are the main challenges to the continued use of this cheap energy source. The electric power industry works with universities and government research organizations to develop more efficient and cleaner technologies and to explore ways of capturing and sequestering carbon dioxide in geological formations. The O_2/CO_2 Combustion System Project, carried out by the CANMET Energy Technology Centre in Ottawa in collaboration with a consortium of utilities, industries, and governmental organizations, is addressing carbon capture. The consortium is studying how to increase the carbon dioxide concentration in the flue gases of power plants by displacing air with oxygen in the combustion process.

Other carbon dioxide management initiatives include the International Test Centre in Regina, Saskatchewan, whose mandate is to reduce the costs of capturing carbon dioxide; the O_2/CO_2 Combustion Process; the Enhanced Recovery of Coal Bed Methane, an Environment Canada-led initiative in which carbon dioxide is injected into deep coal seams, while methane recovery is enhanced; CO_2 Storage Capacity of Canadian Coal Seams (Geological Survey of Canada); and the Canadian Clean Power Coalition, a group of electricity and coal producers who plan to develop and demonstrate low-emission technologies for power plants over the next 10 years.

Natural GHG Uptake

The natural cycles of carbon and nitrogen that control the release and uptake of GHGs are complex, are sensitive to changes in the environment, and vary in space and time. Understanding these cycles and the processes that control them is key to quantifying the amount of GHGs that can be removed from the atmosphere through overt human actions in a verifiable manner and hence be counted as emission offsets under the Kyoto Protocol. The international and Canadian research communities have progressed significantly in improving this understanding. However, much more work is needed before verifiable reporting of GHG uptake through sinks projects will be achievable. Activities in this area will build upon past research into natural processes governing sources and sinks of GHGs within Canada's natural and managed terrestrial ecosystems and adjacent ocean environments.

The overall objective is the development of a better understanding of the relevant GHG cycles and the steps needed to increase net GHG uptake and sequestration from the atmosphere by forest ecosystems, agricultural landscapes, and oceans. The research activities are addressing forest sinks, agricultural soil sinks, ocean sinks, and hydroelectric reservoirs (impacts of biomass flooding on GHGs). Partners include Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, and NRCan.

Examples of National R&D Programs

PERD funds R&D to ensure a sustainable energy future in Canada. It directly supports 40% of all non-nuclear energy research work conducted by federal and provincial governments in collaboration with universities and industry.

PERD funds R&D activities designed to diversify Canada's oil and gas supply, develop cleaner transportation for the future, increase the energy efficiency of buildings, communities, and industry, address environmental issues of the electricity infrastructure, enhance the natural uptake of GHGs, and support the Canadian energy sector's response to the impacts of climate change. Most PERD projects focus on GHG mitigation. However, PERD also supports research on the impacts of climate change on the energy sector (production, transmission, and demand) and adaptation (refer to "Science Impacts and Adaptation Funding and

Coordination Mechanisms" above for further details).

PERD complements the energy-related activities of 11 federal departments and agencies: NRCan (CANMET Energy Technology Centre, Canadian Forest Service, Earth Sciences Sector, and Minerals and Metals Sector), Environment Canada, Transport Canada, Fisheries and Oceans Canada, Agriculture and Agri-Food Canada, Canada Mortgage and Housing Corporation, Health Canada, Indian and Northern Affairs Canada, National Defence, NRC, and Public Works and Government Services Canada. Technologies, knowledge, and standards developed through PERD are deployed through other federal programs, such as Technology Early Action Measures (TEAM), Renewable Energy Deployment Initiative (REDI), IRAP, and Technology Partnership Canada (TPC).

The creation of the Foundation for Sustainable Development Technology in Canada was announced in Budget 2000. The objective of this arm's length, not-for-profit organization is to stimulate the development, demonstration, and dissemination of new environmental technologies, including those aimed at climate change solutions, such as cost-effective renewable energy technologies, energy efficiency, and carbon dioxide management. The initial funding level will be $100 million.

Canada's Perspective on Climate Change, a Compendium of Canadian Initiatives (Climate Change Technology Issues Table, 1999b) provides a good overview of other technology development and deployment programs (www.ec.gc.ca//cc/CoP5/comp/english/intro/intro.htm).

International Activities

The field of climate change is increasing in complexity. International cooperation is necessary because of the breadth of the field. The field is so large and diverse and touches on so many spheres of human activity that no single country has the R&D expertise, money, or facilities to carry out a comprehensive R&D program. International cooperation on technology, whether focused on research, development, or technology transfer, is a key factor in addressing climate change issues. Canada plays a leading and active role in several international R&D activities.

Developing and using improved energy technology is a central part of the International Energy Agency (IEA). The IEA brings together experts from more than 25 countries to work on energy research, development, and demonstration projects under 40 different implementing agreements. Canada participates actively in about 30 implementing agreements. Areas of collaboration include energy end use, renewables, fossil fuels, and fusion. Examples of federal departments, utilities, and companies that participate in these agreements are NRCan, NRC, Public Works and Government Services Canada, Environment Canada, Canada Mortgage and Housing Corporation, Ontario Hydro, Hydro-Québec, Institut National de la Recherche Scientifique, and Ballard Power Systems Inc.

Canada participates in the Energy Working Group of the Asia-Pacific Economic Cooperation forum. One subgroup focuses on standards, training, services, demonstrations, infrastructure development, and modification of renewable energy technologies. Another subgroup works to increase the availability of and access to clean coal technologies.

There are also bilateral collaborative agreements between Canada and other countries. NRCan and the U.S. Department of Energy have a memorandum of cooperation on energy R&D. The memorandum covers all areas of energy R&D except nuclear fission and fusion. As well, Canada has an MOU with the European Union that covers non-nuclear energy, information technology, earth observation, medical and health issues, agriculture and fisheries, and mineral processing.

The Climate Technology Initiative (CTI) was launched at the First CoP in 1995 by 23 IEA/Organisation for Economic Co-operation and Development countries and the European Commission. The CTI's mission is to promote the objectives of the UNFCCC by fostering international cooperation for accelerated development and diffusion of climate-friendly technologies and practices. There are three working groups: capacity building, research and development, and technical assessment, analysis, and strategy. Areas of involvement for the Working Group on Research and Development are carbon dioxide as feedstock for the chemical industry, transportation fuels from biomass,

carbon dioxide ocean sequestration, and large-scale photovoltaic power generation.

Concluding Remarks

The Canadian strategy to address the significant challenge of meeting GHG reduction targets must include sustained R&D to ensure that new technologies are created, developed, and commercialized in the Kyoto timeframe and beyond. It is essential to enhance the supply of market-ready GHG mitigation technologies.

The Climate Change Technology Issues Table identifies four areas where investments are particularly needed:

- in funding new basic and applied R&D to find and develop innovative new solutions;
- in programs to support demonstration of the technical performance and economic viability of new technologies;
- in making improvements to the business environment; and
- in fostering the linkages between the key players in the system.

Canada must develop technologies based on emerging strengths that will translate into reduced GHG emissions domestically and abroad. The following technology areas were identified through the Technology Issues Table consultation process:

- *fossil fuel supply*: natural gas pipelines, advanced technologies to improve efficiency and reduce emissions from fossil fuel production and processing, and technologies for increasing the supply of natural gas;
- *energy supply*: renewable energy, nuclear fission, and stationary gas turbines;
- *energy end use*: fuel cells, buildings, transportation systems, and advanced vehicles;
- *carbon dioxide management*: capture and storage, and biogas; and
- *enabling/cross-cutting technologies*: hydrogen, electrotechnologies, biotechnologies, and energy storage.

Successful development and application of mitigation technologies require collaboration between technology suppliers and technology users, between technology suppliers and technology developers in laboratories and institutes, between the academic community, industry, and laboratories, and between Canadian technology suppliers and international markets.

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www.nrc.ca/irap/home.html

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CHAPTER 9 Education, Training, and Public Awareness

INTRODUCTION

The United Nations Framework Convention on Climate Change (UNFCCC) recognizes the important role of education in the international response to climate change. The UNFCCC refers explicitly to education, training, and public awareness. Article 4(1)(a) indicates that all Parties should "promote and cooperate in education, training, and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organizations."

Article 6 of the UNFCCC expands on this, indicating that Parties must promote:

- the development and implementation of educational and public awareness programs on climate change and its effects;
- public access to information on climate change and its effects;
- public participation in addressing climate change and its effects and in developing adequate responses; and
- the training of scientific, technical, and managerial personnel.

The majority of Canadians (87%) believe in the scientific premise that our climate is changing and that urgent action is needed now. However, while Canadians generally support action on climate change and believe that they can personally address the issue, there remains some confusion over its causes, effects, and solutions. The levels of public awareness and understanding of climate change have been relatively constant since Canada submitted its Second National Report on Climate Change in 1997.

Education, training, and public awareness activities in Canada take many different forms. Over the past several years, Canadian governments (federal, provincial/territorial, and municipal) have been working closely together and within their respective jurisdictions on nationally shared priorities on climate change.

In terms of education and public awareness, these shared priorities include informing Canadians about the science of climate change, the impacts of climate change, actions that can be taken by all sectors of Canadian society to reduce greenhouse gas (GHG) emissions, and adapting to the impacts of climate change. Canadian governments are working closely with various stakeholders, including business and industry, environmental non-governmental organizations (NGOs), community groups, educators, and others, in promoting greater understanding of climate change.

In Canada, "enhancing awareness and understanding" was therefore adopted as one of the five key broad themes comprising Canada's National Implementation Strategy on Climate Change (NIS) (see Chapter 4 for further details).

NATIONAL ACTIVITIES

Public Education and Outreach Issue Table

As part of the 1998 national process to develop Canada's NIS, the Public Education and Outreach (PEO) Issue Table was formed. The PEO Issue Table, consisting of representatives of government, environmental NGOs, and the private sector, developed a PEO strategy entitled Reaching Out to Canadians on Climate Change.

As part of its work, the PEO Issue Table conducted research that evaluated existing outreach initiatives, developed awareness approaches for key audiences, examined barriers to behavioural change, and tested important themes and messages. The PEO Issue Table recommended a long-term, integrated, and sustained public education strategy with three key objectives:

- to build awareness and understanding among Canadians of climate change, including the science, impacts, and adaptation and the associated environmental, economic, and social issues;
- to recognize that climate change is a priority issue and develop support from Canadians for

policy changes and actions that will be required as part of the NIS; and

- to encourage and motivate Canadians to take personal action to reduce GHG emissions.

Canada's First National Climate Change Business Plan (FNBP)

As noted above, Canadians have a strong concern for the environment and a general awareness of climate change, but limited specific awareness and understanding of the causes and implications of climate change as a global and national issue. As a result, Canada's First National Climate Change Business Plan (FNBP) adopted enhancing awareness and understanding (EAU) as one of the broad themes underlying the plan.

EAU is primarily implemented through the activities and programs of the federal and provincial/territorial governments. A cornerstone of the EAU component is the establishment of a national network of regional climate change centres, or hubs, as recommended by the PEO Issue Table. Action has been taken to encourage the development of hubs, on a pilot basis, within jurisdictions across Canada. To date, hubs have been established in Alberta, New Brunswick, the Northwest Territories, Nova Scotia, Saskatchewan, and Yukon. Hubs in other jurisdictions are expected to be established in the near future.

In addition to the hubs, activity is also under way to:

- develop an inventory and synthesis of existing research on public awareness and understanding of climate change;

- establish a national clearinghouse for sharing and coordinating information on EAU activities and tools; and

- develop a "backdrop awareness initiative" to link EAU activities and tools by providing a "common look and feel" that all stakeholders can use.

Anticipated results include the successful establishment of at least four regional pilot hubs, widespread participation in the backdrop awareness initiative, and increased levels of awareness above polling baseline information by 2003.

A national Hub Pilot Advisory Team, with representatives from federal, provincial/territorial, and municipal governments, business, youth, and educators, will encourage information sharing among hubs and provide input to national EAU activities.

Other EAU-related activities at the national level include:

- compilation of a compendium of Canadian initiatives on climate change by federal, provincial/territorial, and municipal governments. The compendium, which lists over 300 policies and measures to address climate change, was published in 1999 and updated in 2000; and

- a project by Canada's federal and provincial/territorial ministers of the environment to collect data on climate change indicators to demonstrate the impacts that changes in climate may be having on Canada's natural environment.

GOVERNMENT OF CANADA ACTIVITIES

Climate Change Action Fund

In 1998, the Government of Canada established the Climate Change Action Fund (CCAF) to support early actions on climate change. Its original three-year mandate was extended for a further three years, beginning in 2001.

Public Education and Outreach

One component of the fund, public education and outreach (CCAF-PEO), supports activities in two areas: awareness and project funding.

Awareness activities have included:

- nationwide print ads urging Canadians to "make the energy link to climate change";

- radio commercials and public service announcements carrying climate change messages;

- an information kit available free of charge to Canadians on various aspects of climate change. The kit includes an overview brochure (Global Climate Change), a "tips" brochure on actions to address climate

change, a science and impacts booklet, a car economy calculator, and several other pieces;

- a Government of Canada Internet site providing information about climate change and about actions Canadians can take to reduce GHG emissions (www.climatechange.gc.ca); and

- a climate change supplement (Our Climate Is Changing) that informed Canadians about the science of climate change, how governments, businesses, and communities are addressing the problem, and actions individuals can take. Seven million copies of the supplement ran in 127 newspapers across Canada, supported by several days of radio advertising in major markets.

In addition, between 1998 and 2001, the CCAF-PEO funded 152 projects, proposed by communities, businesses, and organizations, in six streams: youth, individuals/communities, business, outreach/science, energy efficiency, and transportation. The CCAF invested $18 million in these projects; an additional $33 million was invested by more than 300 partners. Among the projects funded are:

- an energy efficiency caravan with information on different types of energy and their effect on climate, renewable energy, and energy efficiency that will reach up to 20 000 students in Quebec over three years;

- an easy-to-use Internet database of success stories and practical suggestions for reducing GHG emissions created by the Pembina Institute for Appropriate Development. The Web site has received more than two million hits to date (www.climatechangesolutions.com);

- Action by Canadians on Climate Change, a project of the Energy Council of Canada, which is a national grassroots public education and action campaign designed to engage Canadians in meeting Canada's targets under the Kyoto Protocol. The program is based on a series of workplace-based training sessions and uses tools such as pledge cards to encourage action;

- a hands-on interactive exhibit at the Saskatchewan Science Centre that introduces visitors to the topic of climate change and what individuals can do to reduce the causes and impacts;

- Inuit Observations of Climate Change, a video produced by the International Institute for Sustainable Development to demonstrate the effects that climate change is already having on the traditional lifestyles of Canada's Inuit population on Banks Island in the Beaufort Sea;

- a secondary school trip reduction program by British Columbia's Better Environmentally Sound Transportation (B.E.S.T.). This student-designed program encouraged the use of carpools, bicycles, and other means of alternative transportation to reduce automobile trips to selected high schools in the province by 20% over two years. The program won an award from the Organisation for Economic Co-operation and Development for sustainable transportation; and

- residential energy efficiency programs that have resulted in more than 4 000 home visits (energy audits) to promote reduced GHG emissions through residential energy efficiency.

Impacts and Adaptation

Another CCAF component, impacts and adaptation, also contributed to the education and training of Canadians during the CCAF's first three years of operation. Community-based projects on topics such as sea level rise, water resources, infrastructure, and permafrost degradation involved local planners and staff. In many cases, presentations of findings were made to the public or municipal councils. The CCAF also funded workshops that brought together researchers and decision makers to communicate the latest research results in their fields and to discuss potential adaptation measures. For instance, the Water Sector: Vulnerability and Adaptation to Climate Change project entailed a series of five workshops held across Canada to discuss the implications of climate change for water resources. More than 300 water resource managers, landowners, academics, and government officials participated in the workshops.

FEDERAL GOVERNMENT DEPARTMENT ACTIVITIES

Primary responsibility for PEO on climate change within the Government of Canada is shared between two departments: Environment Canada and Natural Resources Canada (NRCan). Other departments, including Health Canada, Transport Canada, and Agriculture and Agri-Food Canada (AAFC), also play a role.

Environment Canada

Environment Canada's mandate is to preserve and enhance the quality of the natural environment. With a budget of more than half a billion dollars and close to 5 000 employees in 100 communities, the department's mission is to make sustainable development a reality in Canada by helping Canadians live and prosper in an environment that needs to be respected, protected, and conserved.

Over the past several years, a number of national outreach projects have been implemented by Environment Canada's Outreach Programs to increase public understanding and involvement in several priority issues, including climate change. National outreach in partnership with communications media has brought success stories, issue information, and action messages to Canadians through products such as public service announcements and camera-ready articles.

Climate change resource materials continue to be made available to teachers and youth leaders, community-based groups, NGOs, municipalities, and other Canadians. The climate change primer, a transportation discussion guide/issue booklet, and a youth-oriented fact sheet are available through the Internet or in traditional print form. As well, an Internet community action site was launched containing information resources, networking opportunities, project ideas, and success stories to support communities taking action on issues including climate change.

Canadian Environment Week themes for the past three years have focused on air issues, giving prominence to the climate change issue and recognition to actions being taken across the country. A climate change forum was held in 1998 in partnership with the Federation of Canadian Municipalities (FCM) to discuss ways for municipalities to reduce emissions.

Through the EcoAction Community Funding Program, Environment Canada provides support to non-profit organizations for community-based projects in support of a healthy environment. Climate Change/Clean Air is one of the priority areas for funding, with 93 projects funded since 1995, for a total investment of $3.6 million. Among the projects the program has supported are:

- a weather-proofing project for low-income housing and a climate change campaign in Peterborough, Ontario;
- a project to encourage the use of energy-efficient lighting by small businesses throughout Nova Scotia; and
- car-sharing initiatives designed to reduce the number of vehicles on the road and reduce GHG emissions in Victoria and Vancouver, British Columbia.

Environment Canada has also been supporting a number of community initiatives focusing on actions that can address both clean air and climate change. These have included early support for the FCM's Partners for Climate Protection Program (see information under "Municipal Government Activities") as well as the coordination of Clean Air Day. Clean Air Day was proclaimed by the Government of Canada in 1999 to increase public awareness and action on climate change and clean air. After only two years, Clean Air Day has become a significant event, supported by both national and multisectoral initiatives in more than 70 large communities across Canada. See Environment Canada's Web site for further information (www.ec.gc.ca).

Natural Resources Canada

The natural resources sector represents over 10% of Canada's gross domestic product. NRCan's mandate is to promote the responsible development and use of Canada's resources with specialization in energy, minerals and metals, forests, and earth sciences. Through its work on policy and leading-edge science and technology, the department encourages sustainable development through the integration of economic, social, and environmental objectives.

NRCan offers programs that have an impact on energy use in all sectors of the Canadian

economy. It provides funding to about 17 programs designed to promote action on energy efficiency, alternative fuels, and renewable energy. These programs include education, training, and public awareness activities.

Most of the programs are coordinated through NRCan's Office of Energy Efficiency (OEE). The OEE was established in 1998 with a mandate to renew, strengthen, and expand Canada's commitment to energy efficiency in order to help address the challenges of climate change, with specific emphasis on the Kyoto Protocol.

In the residential sector, the OEE encourages builders to adopt energy-efficient building practices through the R-2000 Home and EnerGuide for Houses programs and raises public awareness of the energy efficiency opportunities related to both new home construction and renovation. More than 25 000 homeowners have participated in EnerGuide for Houses evaluations of their homes' energy performance. In addition, the EnerGuide labelling program and related promotional activities make buyers aware of the energy performance of appliances and other equipment. Publications on heating and cooling systems are widely distributed, and partnerships with third parties are used to facilitate promotional activities.

As well, the OEE encourages energy efficiency in new commercial buildings through the Commercial Buildings Incentive Program and training of professionals in the field. More than 1 000 architects and engineers have been trained in energy-efficient design in the past three years.

Car owners and new car buyers receive information on the fuel use of new vehicles through a voluntary EnerGuide labelling program on all new vehicles, while fuel-efficient driving practices are promoted through OEE publications and promotional activities. The Auto$mart Student Driving Program provides training to new drivers in energy-efficient practices in partnership with over 900 driver educators across Canada. Best practices in both public sector and commercial vehicle fleets are promoted through the FleetSmart program, which has provided training in fuel-efficient practices to more than 70 000 professional fleet drivers, particularly in the trucking and forestry industries.

Training in energy management techniques as well as promotion of best practices in energy efficiency are also delivered to the industrial, commercial, and institutional sectors through a number of OEE programs designed to actively engage companies in setting targets for reduced energy use and reduced GHG emissions. More than 50 workshops on energy management have been delivered to energy managers in these sectors over the past two years. These programs include extensive outreach in the industrial sector through the Canadian Industry Program for Energy Conservation. The program's members account for more than 80% of energy use in Canada. Additional information on the nature and scope of OEE programs can be found at the NRCan Web site (www.oee.nrcan.gc.ca).

NRCan also promotes the use of renewable energy in the public sector as well as residential markets through the provision of information on renewable energy. Promotional activities include, for example, teaching materials on renewable energy for use in the classroom, delivery of workshops and seminars, support to non-profit renewable energy organizations, and development of Web-based information. In addition, NRCan promotes renewable energy use in remote communities.

Each year, NRCan distributes about 1.5 million copies of more than 300 energy efficiency and alternative energy publications to individuals and organizations. NRCan's Web site (www.nrcan.gc.ca) also provides information on addressing climate change.

Activities at the Earth Sciences Sector represent another way in which NRCan contributes to enhanced awareness and understanding of climate change. Scientists in the sector work to raise awareness of the issue with their industry and community partners through cooperation in research and public information products. The sector has also produced public information products such as the booklet Sensitivities to Climate Change in Canada. Developed in partnership with the other federal science departments, the booklet highlights, using 10 maps, areas of sensitivity to climate change in Canada.

In addition, a series of six climate change posters have been developed, which highlight the regional impacts of climate change across Canada. Copies of the posters will be directed to schools, and an accompanying teacher's guide is being developed. The posters will also be available on-line. It is expected that the posters will have educational value beyond the classroom, helping to inform municipal and other decision makers as well as the general public.

As Canada's largest organization examining the forests' response to climate change, NRCan's Canadian Forest Service (CFS) plays a key role in developing skilled workers, publishing scientific findings, increasing public awareness of climate change, and coordinating activities with industry, universities, NGOs, and other government departments and agencies. The climate change research supported by the CFS provides tools that, in the context of sound forest management practices, will contribute to the ultimate goals of promoting the sustainable development of Canadian forests and reducing GHG emissions and the impacts/adaptations associated with climate change.

In conjunction with the Natural Sciences and Engineering Research Council of Canada, the Social Sciences and Humanities Research Council of Canada, and Energy from the Forest, the CFS funds and supports research efforts among scientists working at CFS's five research centres (e.g., through funding graduate students and post-doctoral research). These programs bring together researchers from government, universities, and industry to work toward sustainable forest management (www.nrcan-rncan.gc.ca/cfs-scf/science/prodserv/meetings_e.html).

CFS climate change scientists are:

- determining and assessing the sensitivity of Canadian forests to climate change;
- determining and assessing the contribution of Canadian forests and their management to the carbon cycle;
- developing estimates of carbon stocks and changes in stocks for Canada's managed and total forests. This work focuses on providing estimates, detailing various forest processes and disturbances, predicting forest responses to climate change, and ascertaining forest management adaptation opportunities and barriers; and
- understanding, predicting, and assessing changes in ecosystem functioning and changes in disturbance regimes related to fires, insects, and diseases (this involves the ability to identify the rate, magnitude, and location of possible impacts) (www.nofc.forestry.ca:80/climate/Home/CCN_English/Factsheets-e/factsheets-e.html).

This work is disseminated through scientific publications, national and international conferences, meetings, and workshops, and the Internet (see CFS links listed at the end of this chapter for a more detailed list of projects currently under way):

- During the 1990s, CFS scientists published about 400 scientific articles and books on climate change and forests (www.nofc.forestry.ca/climate/Home/CCN_English/_Publications-e/publications-e.html).
- The Role of Boreal Forests and Forestry in the Global Carbon Budget was the title and theme of an international scientific conference held in Edmonton, Alberta, in May 2000. The conference provided a forum to discuss the storing of carbon by forests and the impacts of, and adaptation to, climate change in the circumpolar boreal region (http://nofc.cfs.nrcan.gc.ca/carbon/).

The paper Climate Change and Forests: Context for the Canadian Forest Service's Science Program defines climate change in the context of forests and describes why the CFS, in cooperation with its wide range of partners, addresses climate change issues through research, monitoring, and assessment activities in its science and technology research networks (www.nrcan-rncan.gc.ca/cfs-scf/science/context_climate/index_e.html).

The CFS also provides information to the public on various climate change–related topics, such as:

- how to care for damaged trees;

- forest pests in Canada;
- the national forest fire situation; and
- available technologies (www.nrcan-rncan.gc.ca/cfs-scf/science/prodserv/index_e.html)

The CFS newsletter Solutions publishes up-to-date information regarding CFS activities (http://nrcan.gc.ca/cfs/solutions/latest.html).

Transport Canada

Transport Canada is engaged in climate change-related outreach and education activities through several initiatives.

Transport Canada, like other federal departments, prepares a sustainable development strategy every three years. Taking action on climate change is an important component of its 2001–2003 Sustainable Development Strategy. In particular, Transport Canada will work with NRCan and other departments and stakeholders to launch in 2001 the five transportation-related measures outlined in the Government of Canada's Action Plan 2000 on Climate Change (announced in October 2000):

- the urban transportation showcase;
- new vehicle fuel efficiency;
- freight technology and efficiency;
- future fuels; and
- the fuel cell alliance.

Each of these initiatives contains a significant outreach and education component.

Transport Canada's Moving On Sustainable Transportation (MOST) program funds non-governmental projects aimed at promoting sustainable transportation. The program began in the 1999–2000 fiscal year with approximately $1 million to be allocated over three years. To date, the MOST program has allocated approximately $800 000 toward 21 initiatives that will help promote sustainable transportation among diverse target audiences.

Projects supported by the MOST program include:

- the Forest Engineering Research Institute of Canada's research project to design a more fuel-efficient truck that could reduce GHG emissions from forestry hauling operations;
- Greenest City's community project to expand its Active and Safe Routes to School program in southern Ontario. Greenest City works in partnership with communities to encourage children to walk to school safely and to create a safer and healthier atmosphere for children;
- the Canadian Automobile Association's project to develop a series of communiqués that will distribute information on climate change and transportation issues to the Association's four million members as well as to the general public; and
- the Victoria Island for Advanced Technology's project to design and implement an efficient and convenient sustainable transportation system for the Vancouver Island Technology Park.

One of the key objectives of the MOST program is to address the issue of transportation and climate change and to find creative and progressive ways to reduce GHG emissions. Outreach activities are an important part of many funded projects. All funded projects are posted on MOST's Web site (www.tc.gc.ca/envaffairs/MOST/) to enable interested groups and individuals to learn from the experience of others.

Health Canada

As the federal lead department on health and climate change, Health Canada collaborated with the Canadian Urban Transit Association to develop a media campaign for Clean Air Day. This joint effort provided advertising for bus boards and bus shelters to promote alternative and healthier modes of transportation and produced bilingual kits and pamphlets to support messages on health, air pollution, and climate change.

Agriculture and Agri-Food Canada

AAFC addresses a wide variety of environmental issues, such as climate change, biodiversity, ozone depletion, sustainable development, and soil,

water, and air quality. Over the last two years, AAFC has collaborated with experts from the Prairie Farm Rehabilitation Administration (PFRA) to create brochures that engage farmers on climate change and educate them on the benefits of carbon sequestering practices in agriculture. These brochures have been distributed at many venues, including the Conference of the Parties meetings. The brochures include:

- Soil Sinks: Repaying the Carbon Deficit;
- Measuring Soil Carbon Stocks; and
- Agricultural Soil Carbon Sinks and the Kyoto Protocol: A Practical Opportunity for the Environment.

The Climate Change Skills and Knowledge Transfer Program is a five-year (1999–2003) $465 000 program delivered through the Soil Conservation Council's Taking Charge Program. It aims to raise producer awareness of the impact of climate change on the agriculture sector and includes such activities as:

- team development and enhancing the skills/knowledge of provincial teams;
- increasing producer awareness of climate change and how it affects producers;
- helping farmers recognize cost-effective best management practices to achieve GHG emission reductions and soil and water conservation; and
- raising public awareness of agriculture's contribution to GHG reductions.

AAFC's Climate Change Funding Initiative is a four-year (2000–2003) $4 million program designed to enhance the scientific understanding of the agriculture sector's contribution to GHG emissions. Some of the expected outcomes include:

- developing and increasing the pool of experts in climate change; and
- creating science networks (integrated teams of experts and industry partnerships to address knowledge gaps and technology development).

With the support of the CCAF-PEO, AAFC is engaged in three climate change programs:

- The Agricultural Awareness Partnership Project is a collaborative effort between AAFC and key stakeholders: the Canadian Cattlemen's Association, the Soil Conservation Council of Canada, Eastern Canada Soil and Water Conservation Centre, PFRA, and the Canadian Federation of Agriculture. The Project's aim is to increase producer and public awareness of agricultural GHGs and the management practices available to reduce net emissions.
- The Climate Change and Its Impacts on Agriculture, Agri-business and the Rural Community Program has received $289 000 from the CCAF to deliver 30 train-the-trainer sessions on climate change in each of the provinces and territories. These seminars will enable rural community leaders to understand and present the opportunities, risks, and threats associated with global climate change; identify actions to mitigate climate change (reduce industry and community impact upon the environment); and stimulate community action.
- Agriculture, the Optic Industry (a video) is delivered through the Soil Conservation Council of Canada. This 15- to 20-minute video, which received $48 000 from the CCAF, promotes general awareness of the sources of agri-food industry GHG emissions and encourages the adoption of best management practices to reduce emissions.

Further information regarding AAFC's efforts on the environment and PEO activities is available on the AAFC Web site (www.agr.ca/policy/environment/eb).

Scope of the Federal CCAF-PEO Strategy

A review of the specific products, outputs, and activities planned by each CCAF-PEO project, based on plans, indicates the scope and variety of results and outputs that can be expected from the PEO strategy.

In summary form, some of the key outputs identified include:

- training for at least 600 teachers;
- 1 800 presentations to student classes (by meteorologists, scientists, etc.);
- 300 presentations to other target groups (farmers, planners, homeowners, etc.);
- 2 000+ people trained as trainers for their communities;
- exhibitions estimated to reach over two million people;
- 39 sets of kits developed, targeting teachers, students, businesses, community leaders, etc.;
- 27 Web sites developed or enhanced;
- 800 000 copies of articles and publications involving climate change awareness and action to be circulated;
- 18 000 home audits and 250 building retrofits;
- 2 750+ people involved in car pools;
- 200 "greened" schoolyards and 6 000 trees planted;
- 26 000 posters and 3.8 million brochures printed and distributed; and
- 150 public service announcements and six series/documentaries.

In terms of partnerships developed, the review revealed that over 600 groups and organizations have been involved, either as sponsors or as project proponents, in the 137 PEO projects funded through the CCAF by the time of the review. These included:

- 115 environmental groups;
- 100 educational establishments (schools and universities, museums, and nature centres);
- 70+ federal and provincial departments and agencies;
- 38+ municipalities and municipal federations;
- 29 health organizations;
- 21 foundations; and
- 200+ companies and associations from the business sector, including:
  - 75 from the media, communications, and transportation sectors,
  - 50 from the forest, agricultural, construction, chemical, and mining industries, and
  - 50+ from the energy sector.

Financial institutions, consultants, the retail and service sectors, international organizations, and individual citizens were also represented in PEO projects.

FEDERAL GOVERNMENT AGENCY ACTIVITIES

National Round Table on the Environment and the Economy

In 1998, the National Round Table on the Environment and the Economy (NRTEE), an independent agency of the federal government, held a National Forum on Climate Change that brought together 25 Canadians, all members of the Order of Canada, to learn about and assess the climate change challenge. At the end of the Forum, this distinguished group of Canadians concluded that "the time for action is now, and that Canadians have little to lose and everything to gain by taking action immediately" (www.nrtee-trnee.ca).

PROVINCIAL/TERRITORIAL ACTIVITIES

Provincial and territorial governments continue to work to increase public awareness of climate change and to encourage action by individuals to reduce GHG emissions. Many provincial actions are geared toward the education system, which is a provincial responsibility under Canada's Constitution. For example:

- British Columbia has undertaken a series of television programs on climate change through its Knowledge Network;

- Alberta has undertaken a pilot school-based activity and awareness campaign dealing with climate change aimed at Grade 5 students in the province;

- the Northwest Territories has expanded energy management and climate change information in the territory's school curricula; and

- New Brunswick has adopted Destination Conservation, an education and awareness program, in all of its schools.

Other programs being undertaken in Canada's provinces and territories include:

- a toll-free energy conservation telephone service in Saskatchewan;

- support for low-income households in Quebec to become more energy efficient, thus reducing their GHG emissions and their energy bills;

- production of workshops, videos, brochures, and media materials to educate Nova Scotians about climate change;
- Energy Awareness Month, held in November in the Yukon;
- the establishment of the Arctic Energy Alliance in the Northwest Territories to help communities, consumers, producers, regulators, and policy makers to work together to reduce the cost and environmental impacts of energy use in the territory; and
- ClimateWise, a community outreach initiative to understand the barriers that inhibit Albertans from taking action and to stimulate behavioural change.

As well as individual programs, 10 of the 13 provinces and territories have signalled their intent to establish pilot climate change hubs in their jurisdictions.

Further information about EAU activities being undertaken by the provincial/territorial governments, as well as by the Government of Canada, can be found in Canada's FNBP (www.nccp.ca).

MUNICIPAL GOVERNMENT ACTIVITIES

The FCM, supported by the Government of Canada through the CCAF, has created a program entitled Partners for Climate Protection: For a Better Quality of Life. The program supports Canadian municipal governments in preparing and implementing local climate change action plans. The program focuses on building capacity, supporting grassroots leaders (champions), and providing up-to-date information to member municipalities. To date, 72 municipalities, representing 60% of the Canadian population, are members of the Partners for Climate Protection program and are using the Building for Success software to complete GHG inventories of municipal government operations.

NON-GOVERNMENTAL ACTIVITIES

Environmental Groups

Environmental organizations continue to play a vital role in informing the public about climate change and building the capacity of local communities to address the issue. Many of these groups are receiving funding from the Government of Canada through the CCAF. Examples of their activities follow:

- Earth Day Canada is promoting public dialogue on climate change in communities across Canada.
- The Sierra Club of British Columbia has a "Sustainable Living Bus" that is a mobile education centre for learning about climate change. It delivers its program to schools and communities throughout the province.
- The New Brunswick Environmental Network is building capacity among 75 citizen groups to take action at the local level on climate change.
- The Pembina Institute for Appropriate Development has developed a program to engage and brief the media on climate change through half-day seminars in six cities across Canada.
- The Toronto Environmental Alliance is challenging individuals in Canada's largest city to reduce vehicle idling by creating competition among fleet owners as part of its Clean Air Challenge.

Educational Organizations

Through the CCAF, many educational groups have received funding to develop curriculum materials on climate change for students at the elementary and secondary levels. For example:

- Scientists and Innovators in the Schools is developing Climate Change Action Packs for Nova Scotia teachers and schools and is coordinating professional development workshops to better equip teachers to teach climate change in the classroom.

- The Society, Environment and Energy Development Studies Foundation program will teach Canadian secondary school teachers and students about climate change with a bilingual kit of educational resources.

- Greening Schoolyards (Trees for Kids) is an educational public outreach program of the Tree Canada Foundation that disseminates educational material about climate change and facilitates the planting of trees, shrubs, and plants in schoolyards.

- The Global Change Game is an award-winning "live action" simulation workshop with a seven-year history of successful environmental education in Canada.

Private Sector Associations/ Companies

Business and industry in Canada have consistently shown themselves to be concerned about climate change and willing to act to reduce emissions. A survey of 400 senior corporate executives indicates that 71% of executives believe that climate change is a serious problem. More than half (54%) of business executives say that they have taken action over the past two to three years that would help reduce emissions. A further 6% indicate that their firm is currently examining ways to take action.

Many private sector associations and companies, particularly those in the energy production, transmission, and distribution sectors, have developed education programs for employees and their customers that promote the efficient use of energy. Some, such as the Canadian Gas Association, have received funding from the Government of Canada's CCAF to produce an information leaflet for households that provides tips for reducing energy use and GHG emissions. Member companies in the Energy Council of Canada have promoted action on climate change to their employees and customers through CCAF-funded on-site workshops and community outreach.

Other business-related activities that have received funding from the CCAF include:

- energy management initiatives for Toronto neighbourhood retailers, through Greenest City;

- Count-Me-In! workplace workshops, which won Ontario's Top Training Excellence Recognition Award, the top award of the Ontario Society for Training and Development. More than 700 people in 32 workplaces have participated in the workshops;

- a study of the feasibility of establishing a Canadian Alliance on Climate Change, a not-for-profit organization that would communicate the efforts and plans of the business and industrial sectors to reduce GHG emissions; and

- Dalhousie University's School for Resources and Environmental Studies in Nova Scotia, which is developing strategies and technologies for reducing GHG emissions in industrial parks.

THE WAY FORWARD

Canada has a solid track record of achievement in education, training, and public awareness on climate change. Approaches have been piloted, lessons learned, and partnerships and linkages developed. Nonetheless, there is still a need for a long-term sustained effort to increase public understanding of climate change, climate change impacts, and what can be done to reduce emissions and adapt to the inevitable changes. There is also an ongoing need to build public support for policies and measures that are being enacted through Action Plan 2000 (and broader FNBP efforts) and those that will be implemented in the future.

With the foundation solidly in place, Canada's governments, NGOs, businesses, educators, and other stakeholders will continue to work to meet the requirements of the UNFCCC for education, training, and public awareness on climate change.

REFERENCES

Internet Sites

The main site for information on climate change is located at www.climatechange.gc.ca.

Canadian Intersite Decomposition Experiment (CIDET)
www.pfc.cfs.nrcan.gc.ca/climate/cidet/index_e.html

Climate Change and Forest Fire in Canada
www.nofc.forestry.ca:80/fire/frn/English/ClimateChange/ClimateChange_e.htm

Climate Change Impacts on the Health and Productivity of Aspen
www.nofc.cfs.nrcan.gc.ca/cipha/

Conferences, Meetings, Workshops, and Publications Digest
www.nrcan.gc.ca/cfs-scf/national/what-quoi/publications_e.html

Environment Canada
www.ec.gc.ca/climate/index.html

Extended Collaboration for Linking Ecophysiology and Forest Productivity (ECOLEAP)
www.cfl.cfs.nrcan.gc.ca/ECOLEAP/home.html

Natural Resources Canada (NRCan)
climatechange.nrcan.gc.ca

NRCan (Canadian Forest Service – CFS)
www.nrcan.gc.ca/cfs-scf/

Visualization of Climate Change scenarios
www.pfc.cfs.nrcan.gc.ca/climate/index_e.html

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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Agriculture / Aquaculture					
Government of Canada					
Agricultural Environmental Stewardship Initiative	Addresses the impacts of agricultural practices on water, soil, and air quality, biodiversity, and GHG emissions.	N_2O, CH_4, CO_2, NH_3	Education Information	Implemented	Agriculture and Agri-Food Canada
Agro-Climate Monitoring and Information Transfer	Includes analyzing alternative long-term strategies for drought monitoring, reporting, and responses, and the application of long-range climate forecasts to prairie agriculture. Activities also include identification of long- and short-term climate trends and their impact on long-range climate forecasts.	N_2O, CH_4, CO_2	Voluntary Research	Implemented	Prairie Farm Rehabilitation Administration
Agro-Ecosystem Research	Extensive research studies aimed at reducing uncertainties in agro-ecosystem emissions estimates; comparisons of modelling methods; emissions estimates from manured fields and during composting; seasonal GHG fluxes from soils in different prairie soil zones; farm-level GHG measurement; expert systems to assess the effect of different agricultural management practices on GHG emissions; and understanding the soil carbon storage mechanism, nitrogen flows, and N_2O emissions.	CO_2, CH_4, N_2O	Research	Implemented	Agriculture and Agri-Food Canada
Canadian Adaptation and Rural Development Fund	To increase research capacity and coordination to position the agriculture sector to respond to climate change.	N_2O, CH_4, CO_2	Research	Implemented	Agriculture and Agri-Food Canada, Canadian Agri-Food Research Council
Canadian Economic and Emissions Model for Agriculture	An integrated agro-ecological economic modelling system that can be used to simultaneously assess the economic and GHG emission impacts of agricultural policies at regional and national levels. The model is a quantitative tool that can contribute to climate change goals through analyses of changing agricultural economics and production practices relative to patterns of GHG emissions.	N_2O, CH_4, CO_2	Research	Implemented	Agriculture and Agri-Food Canada

Government of Canada (continued)					
Climate Change Funding Initiative	Improves the scientific understanding of the agriculture sector's contribution to GHG emissions through four major components: developing and increasing the pool of experts in the field of climate change, placing priority on the creation of science networks, where integrated teams of experts and industry partnerships address fundamental knowledge gaps and technology development, the dissemination of information, and the coordination of climate change activities in Canadian agriculture.	N_2O, CH_4, CO_2	Research Information	Implemented	Agriculture and Agri-Food Canada, Canadian Agri-Food Research Council
Climate Change Skills and Knowledge Initiative	Increase awareness of producers as to the impact of climate change on the agriculture sector, including the coordination and development of "grassroot" provincial teams to raise farmers' awareness of climate change issues; the development of information tools; the holding of provincial workshops on GHG-reducing activities; and a national conference to further raise understanding of climate change issues.	N_2O, CH_4, CO_2	Information	Implemented	Agriculture and Agri-Food Canada, Soil Conservation Council of Canada
Community Pasture Program	To remove lands from unsuitable or unacceptable land uses and to facilitate improved land use through their rehabilitation, conservation, and management.	CO_2, CH_4, N_2O	Voluntary	Implemented	Prairie Farm Rehabilitation Administration
Countryside Canada	Recognition and award program for on-farm/ranch stewardship.	CO_2	Voluntary Information	Implemented	Wildlife Habitat Canada, Canadian Federation of Agriculture
Environmental Rehabilitation and Food Security – Mali	This project builds capacity in local, decentralized institutions to deal with natural resource management and supports specific environmental interventions as they relate to both adaptations to desertification due to climatic changes and issues of improved food production.	CO_2	Information	Implemented	Canadian International Development Agency, Unitarian Service Committee, Government of Mali
Green Fund Extension – Jamaica	This project supports community-based initiatives that will contribute to the sound management and conservation of Jamaica's natural resources and improve advocacy and development through more effective networking. Projects have dealt with improved agriculture and agro-forestry practices and alternative sources of energy.	CO_2	Policy Information	Implemented	Canadian International Development Agency

Government of Canada (continued)					
Hebei Dryland Project – China	This project develops and transfers ecologically sound dryland management technology and improves water efficiency, as well as balanced fertilization practices.	N_2O	Information	Implemented	Agriculture and Agri-Food Canada, Canadian International Development Agency
Hog Environmental Management Strategy	A partnership between the federal and provincial governments and the hog industry that provides a coordinated approach to finding effective and affordable solutions to the environmental challenges facing the industry. Environmental issues in hog production pertain primarily to the storing, handling, and application of manure. The three key concerns are odours, soil and water quality, and air pollution (which includes the GHGs CH_4 and N_2O).	N_2O, CH_4	Voluntary Research Information	Implemented	Agriculture and Agri-Food Canada
Irrigation and Water Management Technology Transfer	Demonstrates appropriate management techniques for water and fertilizer applications to improve the efficiency of the production system.	CO_2, CH_4	Voluntary Research	Implemented	Prairie Farm Rehabilitation Administration
Livestock Environmental Initiative	This initiative includes two components: research and development, as well as assessment and transfer of technology to the livestock industry; and an assessment of possible environmental certification systems for the hog industry.	CH_4, N_2O	Research Technology Transfer	Implemented	Agriculture and Agri-Food Canada, Livestock Initiative National Committee, Canadian Pork Council
Marginal Land Information Management	Addresses conversion of environmentally sensitive lands in annual cultivation to more appropriate forage and pasture. In addition, significant carbon sequestration potential is estimated on these lands.	CO_2	Voluntary Research	Implemented	Prairie Farm Rehabilitation Administration
Matching Investment Initiative	Increase collaborative research activity between the private sector and government. The initiative, by involving industry research investors directly, will also help speed up the process of transferring new technology to the private sector. The initiative also contributes to the promotion and implementation of GHG-reducing practices in such areas as soil nutrient management, manure management, grazing strategies, feeding strategies, water management, agro-forestry, food processing, and soil carbon sequestration.	CO_2, N_2O, CH_4	Fiscal Research	Implemented	Agriculture and Agri-Food Canada

Government of Canada (continued)					
Natural Resource Management – Honduras	This project seeks to build capacity for effective policies related to the sustainable management of natural resources, including forests, agricultural land, water, and marine/coastal areas. Subcomponents of the project focus on helping Honduras establish a focal point for participation in the Clean Development Mechanism and a Cleaner Production Centre, as well as sponsoring a study on energy efficiency opportunities in Honduras.	CO_2	Policy	Implemented	Canadian International Development Agency
Nutrient Management and Strategies for Sustainable Development – China	This project aims to promote environmentally sustainable development by enhancing the capacity of farmers, decision makers, and policy makers in China to promote the balanced use of fertilizers and improved soil management.	CO_2, N_2O	Policy Information Voluntary	Implemented	Canadian International Development Agency, Phosphate & Potash Institute of Canada, Canadex
Permanent Cover Program	The primary objective is to reduce soil degradation on environmentally sensitive lands that have high erosion risk under annual cultivation. Marginal lands were targeted for conversion to alternative sustainable uses under permanent cover.	CO_2	Voluntary	Implemented	Prairie Farm Rehabilitation Administration
Range Management Technology Transfer	Working to develop firmer supporting science on carbon sequestration potentials and other GHG impacts.	CO_2, CH_4, N_2O	Voluntary Research	Implemented	Prairie Farm Rehabilitation Administration
Shelterbelt Program	A permanent program for the distribution of seedlings to farmers and Conservation Boards for planting shelterbelts or for conservation and land reclamation projects. This program includes a research component (tree improvement, agro-forestry, and carbon sequestration) and a communications component. Direct results from this program include the creation of wildlife habitat, conservation of soil, sequestration of carbon, significant energy reductions in farmsteads, management of snow, and stabilization of crops.	CO_2	Voluntary Research	Implemented	Prairie Farm Rehabilitation Administration

Government of Canada (continued)						
Soil Management, Manure Management and Resource Planning Activities	Offers soil management advice on topics such as tillage, summer fallow, cropping, stubble management, straw harvest, manure management, intensive livestock sitting, and riparian area management. Ongoing planning with and for clients in the prairie region, as well as offering analytical services on resource conservation and development issues.	CO_2, CH_4, N_2O	Voluntary Research	Implemented	Prairie Farm Rehabilitation Administration	
Alberta						
Agricultural Food Processing Practices	The program allows for agricultural food processors in Alberta to provide significant savings in energy costs and reduce GHG emissions from facilities. Complete energy audits on 34 companies representing 46 processing facilities.	CO_2, CH_4	Information	Implemented	Government of Alberta	
Alberta Reduced Tillage Initiative	Coordinates and presents programs and activities that disseminate quality, practical production information that will lead to the adoption of reduced tillage technology by Alberta producers. The partnership is based on a common philosophy about the benefits of reducing the amount and intensity of tillage. The GHG benefit is reduced fuel use and increased carbon storage in soil, which helps to reduce net GHG emissions.	CO_2, CH_4	Information	Implemented	Alberta Agriculture, Food and Rural Development	
Education and Awareness Program for Food Producers	Raise awareness and understanding of how adopting GHG-reducing management practices now can create savings in the future.	CO_2, CH_4	Information Education	Implemented	Alberta Agriculture, Food and Rural Development	
Farm Business Management Program	This program focuses primarily on improving financial and other business management skills. Production (nutrient) management is one component of the program that can provide GHG reduction benefits.	CO_2, CH_4	Voluntary Information	Implemented	Alberta Agriculture, Food and Rural Development	
Greenhouse Gas Program for Agriculture	Focuses on identifying best practices that support climate change mitigation and adaptation.	CO_2, CH_4	Information	Implemented	Alberta Agriculture, Food and Rural Development	

Alberta (continued)					
Prairie Soil Carbon Balance Research Study	Supporting a multiyear research study to better understand soil carbon dynamics. The purpose of the study is to develop scientifically sound methods to assess changes in soil carbon based on management practices.	CO_2, CH_4	Research	Implemented	Alberta Agriculture, Food and Rural Development
Regulatory Framework for Livestock Feeding Operations	One component of this proposed framework for Alberta is a standards document to deal with manure storage and nutrient management. This is a way to identify and encourage adoption of practices and technologies to reduce GHG emissions.	CO_2, CH_4	Voluntary Information Technology Transfer	Adopted	Alberta Agriculture, Food and Rural Development
British Columbia					
Adaptation in Fisheries Sector	Activities include researching climate change impacts on fish and fish habitat; establishing gene banks to protect diversity of fish populations affected by climate change; cooperating with other agencies to restore fish habitat; adopting technology and techniques for selective fisheries; developing and diversifying new fisheries; and communicating with professionals and the public. In addition, changes to the *Fish Protection Act* and related regulations protect in-stream flows for fisheries and riparian vegetation, helping to mitigate climate change impacts.	n.a.	Research Information Regulatory	Implemented	Ministry of Agriculture, Food and Fisheries
Agricultural Soil Carbon Sequestration Potential	Research will enable development of a policy for the accounting of agricultural soil sinks. Alternative cropping practices will be identified for areas with a potential to increase soil organic matter.	CO_2	Research Information	Adopted	Ministry of Agriculture, Food and Fisheries
Consultation and Extension on Agricultural Practices	Workshops and information sessions to explore agricultural practices that reduce or sequester GHG emissions.	CO_2, CH_4, N_2O	Information	Implemented	Ministry of Agriculture, Food and Fisheries

Name of Policy/ Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Ontario					
Agricultural Best Management Practices	Provide farming sector with current technical advice on soil and water conservation and management of GHG-producing agricultural activities, with focus on farm nutrient management and reduced tillage.	CO_2, CH_4, N_2O	Voluntary Information	Adopted	Ministry of Agriculture, Food and Rural Affairs
Ontario Agrometeorology Research and Services Committee	Current research to understand N_2O emissions from agricultural systems has required that NO and NO_2 fluxes be measured. The latter gases are also central to the chemistry of ground-level ozone; therefore, a spinoff emerging from the N_2O research is a better understanding of the holistic role of agricultural surfaces in regional air quality. Preliminary modelling suggests that agriculture is a strong sink for both ozone itself and its precursors.	N_2O	Research	Implemented	Ministry of Agriculture, Food and Rural Affairs
New Brunswick					
Agriculture Initiatives	Support proposals to strengthen the adoption of new technology, to improve the education and awareness of livestock producers on best management practices that reduce odour and methane emissions, and to advance the proper storage and handling of manure.	CO_2, CH_4	Voluntary Information	Implemented	Department of Agriculture and Fisheries
Nova Scotia					
Annapolis Atmosfarm Project	The purpose of the project is to increase understanding of climate change, reduce GHG emissions, and increase carbon sequestration on commercial farms. In addition, the project will identify longer-term measures for the agricultural industry.	CO_2, CH_4, N_2O	Voluntary Information	Implemented	Clean Annapolis River Project, Environment Canada, Acadia Centre for Estuarine Research, Nova Scotia Natural Resources, DalTech, Agriculture and Agri-Food Canada, Nova Scotia Organic Growers Association, Annapolis County of Agriculture, Nova Scotia Agriculture and Marketing
Prince Edward Island					
Capture and Use of Methane Gas at Agri-food Processing Plants	To capture CH_4 and use it as a replacement for heavy fuel oil.	CO_2, CH_4	Economic	Implemented	PEI Department of Fisheries, Aquaculture and Environment

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Prince Edward Island (continued)					
Livestock Management and Grazing Management	To reduce emissions from digestive processes and manure storage and application; to increase nutritional quality of pasture grasses. The focus will continue to be on fencing and watering options to prevent livestock access to watercourses and to prevent water contamination by manure.	CH_4, N_2O	Voluntary Information	Implemented	PEI Department of Agriculture and Forestry
Quebec					
Increased Yield Policy	Planting program for species of trees that grow rapidly on wild lands unsuitable for agricultural purposes.	CO_2	Policy	Adopted	Department of Agriculture, Fisheries and Food
Saskatchewan					
Agricultural Burning Awareness Program	Pilot is being expanded to increase farmer awareness and to provide information to farmers leading to improved decision making and to encourage reduction/stopping of crop residue burning.	CO_2	Voluntary Information Technology Transfer	Implemented	Saskatchewan Agriculture and Food, Saskatchewan Health, Regina Health District, Saskatchewan Environment and Resource Management, Rural Municipalities, Environment Canada
Conservation Cover Program	This program is a four-year initiative of the Saskatchewan government to contribute to the converting of cropland to perennial cover.	CO_2, CH_4, N_2O	Fiscal Education	Implemented	Saskatchewan Agriculture and Food
Crop Nutrient Management	Extension of soil fertility management practices/cropping systems for major and diversified crops to maximize nutrient use efficiency while sustaining and improving the health of soil. Soil and plant tissue testing are major tools in achieving this objective, along with information on the form, timing, and placement of fertilizers, with a focus on nitrogen.	CO_2, CH_4, N_2O	Promotion Information Research		Saskatchewan Agriculture and Food, University of Saskatchewan, Agriculture and Agri-Food Canada, Industry Canada
Greenhouse Gas Initiatives in Saskatchewan Agriculture	This initiative will summarize the currently available information on GHG and carbon sequestration in Saskatchewan agriculture and review and discuss policy options for emission abatement. It will also identify various economic scenarios for the Saskatchewan agriculture industry and producers and provide options and recommendations.	CO_2, CH_4, N_2O	Policy	Implemented	Saskatchewan Agriculture and Food

Name of Policy/ Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Saskatchewan (continued)					
Improved Grazing Management	Improve and sustain rangeland and pasture resources through continued research and providing technical advice and training to producers involved in range/livestock production and to encourage multiple use of rangeland and environmental sustainability.	CO_2, CH_4, N_2O	Voluntary Information Technology Transfer	Implemented	Saskatchewan Agriculture and Food, Grazing and Pasture Technology Program, Prairie Farm Rehabilitation Administration, Saskatchewan Stock Growers Association, Agriculture and Agri-Food Canada
Processing of Surplus Crop Residues	Encourage processing of surplus crop residues to produce value-added products (fibre products, strawboard, alternative energy products).	CO_2	Voluntary Research Economic Technology Transfer	Implemented	Saskatchewan Agriculture and Food, Industry Producers
Pulse and Legume Crop Diversification	Pulse and legume crop diversification assists in achieving sustainability; pulses and other legumes fix nitrogen from the air, reducing the need for nitrogen fertilizer; value-added processing encouraged locally; encourages longer rotations and reduction in summer fallow acres.	CO_2, CH_4, N_2O	Voluntary Legislative Economic Research Information Technology Transfer	Implemented	Saskatchewan Agriculture and Food, Crop Development Centre, University of Saskatchewan, Agriculture and Agri-Food Canada, Industry Producers
Soil Conservation	Soil conservation projects reduce the loss and enhance the productivity of valuable topsoil. Building soil organic matter (carbon sequestration) and reducing soil erosion are the two main focuses. Practices include reduced tillage, zero-till, field shelterbelts, grass strips, strip cropping, etc.	CO_2, CH_4, N_2O	Voluntary Research Information Technology Transfer	Implemented	Saskatchewan Soil Conservation Association
Strategy for Sustainable Manure Management	Managing manure as a resource. Manure when used properly can be a valuable source of plant nutrients and organic matter to improve crop production and soil quality. Manure is a source of soil organic matter (sequestered carbon).	CO_2, CH_4, N_2O	Voluntary Legislative Policy Research Information Technology Transfer	Implemented	Saskatchewan Agriculture and Food, Beef Development Centre, Industry Producers, University of Saskatchewan, Agriculture and Agri-Food Canada

Name of Policy/ Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Buildings					
Government of Canada					
Advanced Integrated Mechanical Systems	This initiative is designed to help manufacturers develop products and the market infrastructure for natural gas–fuel appliances that integrate ventilation, space, and hot-water heating into a single system.	CO_2	Research	Implemented	Natural Resources Canada
Building Heat Management Research Program	The purpose of this program is to develop and disseminate knowledge and technology that will contribute to a reduction in GHG and other emissions through improvements in building energy efficiency, and help build the energy efficiency industry in order to capture growing domestic and international markets.	CO_2	Research Information	Implemented	Natural Resources Canada
Buildings Energy Technology Advancement Plan	A cost-sharing program aimed at developing, commercializing, and encouraging the adoption by industry of a new generation of technologies and residential and large buildings with improved energy efficiency and indoor air quality.	CO_2	Technology Transfer	Implemented	Natural Resources Canada
Commercial Buildings Incentive Program	This program provides financial incentives to encourage building owners to incorporate energy-efficient technologies and practices in designs for new commercial and institutional buildings.	CO_2	Economic Information	Implemented	Natural Resources Canada
EnerGuide for Houses	The program encourages Canadians to improve the energy performance of their houses. Homeowners receive advice from independent energy efficiency experts on how to improve home comfort and reduce heating and cooling costs when making home improvements.	CO_2	Information	Implemented	Natural Resources Canada
Federal Buildings Initiative (FBI)	Helps organizations manage energy costs, while making their facilities more comfortable and productive workplaces. The program offers, to executive and managerial support, a complete package of tailored technical, planning, and contractual support needed to implement an energy-saving project on a turnkey basis. The FBI also offers access to tools and services to assist organizations in planning a strategy to implement energy efficiency in federal buildings.	CO_2	Information	Implemented	Natural Resources Canada

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Government of Canada (*continued*)					
Federal House In Order Strategy	A Government of Canada initiative to demonstrate federal leadership in the reduction of GHG emissions. The government's aim is to lower emissions from its own operations to an amount comparable to what is expected of all other Canadian organizations. An emissions reduction target for 2010 is being determined for the federal government as a whole, based on information provided by departments.	CO_2	Policy Information	Adopted	Natural Resources Canada, Lead Federal Departments
Federal Industrial Boiler Program	The Federal Industrial Boiler Program ensures that energy-efficient and environmentally responsible technologies are considered when federal departments, agencies, Crown corporations, or private sector clients replace or modify their heating and cooling systems. Program develops site-specific strategies to help building operators meet higher equipment performance targets and provides turnkey project management services on new or retrofit projects. These management services include preparing technical specifications, reviewing tenders, and overseeing the installation and commissioning of new equipment.	CO_2	Information Research	Implemented	Natural Resources Canada
Green Power Procurement Initiative	This initiative commits the Government of Canada to displacing purchases of high-carbon electricity with electricity from emerging renewable sources, referred to as "green power." In addition to reducing GHG and other emissions in federal operations, this initiative provides a demand for green power and encourages electric utilities to market this type of power to other customers.	CO_2	Policy	Implemented	Natural Resources Canada, Environment Canada
Healthy Housing	Program aims to foster change in how new homes are built, how existing homes are renovated, and how communities are planned. Program is based on five principles: occupant health, energy efficiency, resource efficiency, environmental responsibility, and affordability.	CO_2	Research	Implemented	Canada Mortgage and Housing Corporation
Heating, Ventilation and Air Conditioning Energy Efficiency Rating System	This program provides consumers with energy efficiency ratings for gas and propane furnaces, central air conditioning equipment, and air-to-air heat pumps. Oil-fired furnaces will soon be added to the rating system. Ratings are published at the back of manufacturers' brochures in order to provide consumers with the	CO_2	Information Technology Transfer	Implemented	Natural Resources Canada

Government of Canada (continued)					
	information needed to purchase energy-efficient home heating and air conditioning products. This program is operated in association with the Heating, Refrigeration and Air Conditioning Institute, which provides contractors with the tools to promote the sale of more energy-efficient equipment.				
Industrial Buildings Incentive Program	This program will offer an incentive to companies building new industrial facilities to offset additional design costs inherent in the initial attempts at energy-efficient designs. 59 contribution agreements covering 59 buildings, and 18 training workshops resulting in 1 000 trained professionals.	CO_2	Economic Policy	Implemented	Natural Resources Canada
Model National Energy Code for Buildings and Houses	This program aims to increase the energy efficiency of new Canadian houses and buildings by specifying minimum energy requirements, supporting the implementation and adoption of these model national energy codes by relevant authorities having jurisdiction for buildings and houses, and monitoring and analyzing the impact of such codes.	CO_2	Policy	Implemented	Natural Resources Canada
R-2000 Home	The R-2000 Home program uses a quality assurance process to ensure that certified R-2000 houses meet the voluntary performance standard for energy efficiency, indoor air quality, and environmental sustainability. The program is delivered provincially by more than 30 industry partners and provides technical support, builder training, and industry infrastructure.	CO_2	Voluntary Information	Implemented	Natural Resources Canada
Refrigeration and Intelligent Buildings	This program focuses on the development and deployment of technologies in the areas of ground source heat pumps, refrigeration, and intelligent buildings.	CO_2	Technology Transfer	Implemented	Natural Resources Canada
Renewable Energy Deployment Initiative	This program promotes renewable energy systems for space and water heating and for cooling through an incentive that funds 25% of the cost of adopting new systems (to a maximum of $50,000). Eligible systems include solar air heating, solar water heating, and high efficiency/low emission biomass combustion. Initiative also provides market support for earth energy systems and supports pilot projects in the public institutions and residential markets.	CO_2	Economic Technology Transfer Information	Implemented	Natural Resources Canada

Government of Canada (continued)					
Sponsorship Program	Provides Canadian homeowners with consumer information on residential energy efficiency through a network of sponsors that includes hardware and building supply retail sectors, utilities, media, and industry associations.	CO_2	Information	Implemented	Natural Resources Canada
Alberta					
Alberta Government Voluntary Challenge and Registry Action Plan	Sets an overall target for reduction of Alberta government emissions from 1990 levels by the year 2000, reduction of its GHG emissions to below 1990 levels, and exceeding the emission targets in both quantity and time.	CO_2	Voluntary	Implemented	Alberta Environment
CO_2 Diet Program In-reach Initiative	Program encourages government staff to take personal action to reduce GHG emissions at work and at home. The program involves bi-weekly educational sessions on topics such as climate change science, policy, and personal action, featuring speakers from government, industry, and non-governmental organizations.	CO_2	Voluntary Information	Implemented	Alberta Environment
Destination Conservation School Retrofit Program	Enrols school jurisdictions in a retrofit program. Students, teachers, and other school staff audit their school's energy consumption and develop plans to reduce consumption through retrofits and lifestyle changes.	CO_2	Information	Implemented	Alberta Environment
Energy Efficiency Standards for New Schools	New standards and guidelines have been created for the building of new schools and modernization of existing ones.	CO_2	Policy	Implemented	Government of Alberta
School Buildings Guidelines	Development of new standards and guidelines for the building of new schools and the modernization of existing ones. These guidelines incorporate life cycle costing and energy efficiency requirements.	CO_2	Policy	Implemented	Alberta Environment
British Columbia					
Energy Measures	Piloting energy efficiency upgrades of schools and other publicly funded buildings.	CO_2	Policy Information	Implemented	BC Hydro, Ministry of Finance, Ministry of Employment and Investment, Ministry of Energy and Mines

British Columbia (continued)						
Green Buildings	Facilitates growth of the British Columbia green buildings sector through strengthening networks, facilitating opportunities, and building alliances that attract investment and expand exports.	CO_2	Information		Implemented	Ministry of Employment and Investment
Green Buildings – New Buildings Program	The program objective is to develop a policy for the incorporation of green building principles and practices in the design of provincially funded buildings. Development of this policy will be informed by a series of pilot projects that will incorporate sustainable development principles. The goal of the program is to develop government facilities consistent with the concept of responsible and sustainable development.	CO_2	Policy		Implemented	Ministry of Employment and Investment, Ministry of Finance and Corporate Relations
Green Buildings – Retrofit Program	Provides opportunities for provincially funded schools, universities, colleges, and health care institutions to upgrade existing facilities with energy and water efficiency enhancements, as well as waste-saving measures.	CO_2	Technology Transfer		Implemented	Ministry of Employment and Investment, Ministry of Finance and Corporate Relations
Tax Exemption for Energy Conservation Materials and Equipment	A provincial sales tax exemption is provided for certain energy conservation materials and equipment, including insulation materials for buildings (e.g., various types of insulation material, double-paned windows, doors) and certain wind, solar, and micro-hydro equipment.	CO_2	Economic		Implemented	Ministry of Finance and Corporate Relations
New Brunswick						
Energy Accounting	The objective of the program is to provide energy accounting information to government building managers, which will allow them to manage energy use. Activities involve the collection, analysis, and reporting of energy use.	CO_2	Information		Implemented	Government of New Brunswick
Energy Efficient Standards for Buildings	The objective of this program is to increase the level of energy efficiency in new facilities by promoting the use of energy efficiency standards for buildings. A variety of activities are undertaken to support this effort. New Brunswick is a member of the Canadian Consortium for Building Energy Compliance Software, which has released a software package that measures compliance under the Model National Energy Code for Buildings. The province also supports R-2000 and requires that social housing be built to the R-2000 standard. The penetration	CO_2	Technology Transfer Voluntary Information		Implemented	Government of New Brunswick

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New Brunswick (continued)					
	of R-2000 homes in New Brunswick has had a significant impact on the standard levels of energy efficiency in new homes, which are close to the R-2000 standard.				
Provincial Buildings Initiative	The objective is to improve energy efficiency in government-owned buildings. The initiative uses energy performance contracting as a delivery mechanism. All directly funded government facilities are being considered for improvements, including physical retrofits, training, and awareness activities.	CO_2	Information Education	Implemented	Government of New Brunswick
Northwest Territories					
Energy Conservation Capital Program	Program assists territorial and community-funded departments, boards, and agencies, as well as non-profit organizations, by providing grants to support and finance projects that reduce usage of electrical and heat energy and water.	CO_2	Economic	Implemented	NWT Housing Corporation, NWT Association of Municipalities, NWT Public Utilities Board
Good Building Practice for Northern Facilities	Preparation of a set of building design guidelines to help ensure that facilities are designed and constructed to minimize life cycle costs. As utility costs are a major component of the owning and operating costs of a facility, there is considerable emphasis on energy efficiency in the guidelines.	CO_2	Information	Implemented	NWT Housing Corporation, NWT Association of Municipalities, NWT Public Utilities Board
Inuvik Conversion Assistance Program	This program provides financial assistance to residential homeowners to convert from oil heat to natural gas. The amount of the grant is matched by the gas supplier. The major objective of the program is to assist in the rapid conversion of residential homeowners to a local, cleaner energy source for heating.	CO_2	Economic	Implemented	NWT Housing Corporation, NWT Association of Municipalities, NWT Public Utilities Board
Nova Scotia					
Commercial Buildings Incentive Program	Use of energy simulation modelling and incentives to encourage use of optimal investment in energy efficiency in new buildings and retrofits.	CO_2, N_2O	Information Economic	Implemented	Government of Nova Scotia, Government of Canada
Energy Efficient Housing	Education and awareness on energy-efficient new housing and retrofit.	CO_2	Information	Implemented	Department of Natural Resources

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nova Scotia (continued)					
Halifax Home Tune-Up Program	The goal of this two-year program is to improve energy efficiency, conserve water, and improve waste management practices and air quality in 2 000 homes in the greater Halifax area, by providing low-cost in-house environmental assessments. Homeowners receive written reports, including recommendations for improvements, an information package, a water conservation kit, and a list of long-term retrofits requiring contractor assistance.	CO_2	Information Voluntary Economic	Implemented	Department of Natural Resources
Light Better for Less	Improve lighting efficiency in small commercial operations. Electrical contractors are trained to perform lighting energy audits on small commercial facilities and recommend and install energy-efficient lighting. Wholesalers are asked to increase stock of lighting projects. Seminars and other marketing are directed at small commercial operators.	CO_2, N_2O	Information Voluntary	Implemented	Department of Natural Resources
Residential Energy Advisory Service	This program encourages the use of energy efficiency measures and renewable energy in new home construction and renovation. Activities are directed at contractors and homeowners. The program includes support for R-2000 Home program, EnviroHome projects, energy-efficient and renewable energy demonstration projects, and publications and videotapes on energy efficiency.	CO_2	Economic Voluntary Information	Implemented	Department of Natural Resources
Ontario					
Amendments to the Ontario Building Code	Amendments allow designers and builders to introduce more cost-effective energy efficiency measures to reduce GHGs, as well as facilitate the use of recycled building materials.	CO_2	Regulation	Implemented	Ministry of Municipal Affairs and Housing
EnerGuide for Houses	Provides a means for homebuyers to measure energy efficiency by providing information on energy-efficient housing.	CO_2	Information	Implemented	Ministry of Energy, Science and Technology
Reduction in Government Facilities and Operations	Program seeks to reduce GHG emission from government facilities and operations by 40% from the 1990 baseline levels.	CO_2	Policy	Implemented	Ministry of Environment

[illegible]	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Quebec					
Energy Efficiency Action Program in the Institutional Sector	The program provides financial support to encourage institutions to change their ways and promote energy efficiency. This assistance is intended for institutions that conduct energy analyses and feasibility studies that lead to the implementation of measures or projects designed to reduce energy bills by 10%.	CO_2	Voluntary Information	Implemented	Energy Efficiency Agency
NOVOCLIMAT Program	The goal of this program is to support initiatives designed to improve the energy performance of new houses by training and accrediting persons involved in the residential construction sector. The program will make it possible to develop a product and skills that will benefit consumers.	CO_2	Information	Implemented	Energy Efficiency Agency
Rules Governing Energy Performance Contracts	Amendment of the regulations governing construction contracts to allow all parts of the education system to award contracts designed to achieve savings as a result of energy improvements to buildings. These contracts are paid for with the savings achieved and include both professional services and construction work.	CO_2	Regulatory	Implemented	Government of Quebec
Saskatchewan					
EnerGuide for Houses	Objective is to further improve the energy efficiency and reduce the environmental impact of Canadian low-rise housing. EnerGuide for Houses evaluates the energy-related features of a house, estimates the home's annual energy requirements, and provides a comparative energy efficiency rating.	CO_2	Information	Implemented	Sun Ridge Group, Saskatchewan Energy and Mines, Natural Resources Canada
Energy Management Initiative	This initiative makes affordable improvements to health facilities to obtain optimum energy efficiency and cost benefits.	CO_2	Technology Transfer Information	Implemented	Saskatchewan Health
Energy Reduction Program	An initiative to modify or replace inefficient building systems such as lighting and heating, ventilation, and air conditioning systems, as well as to install building control systems to increase the energy efficiency of government-owned buildings. The goal of the program is to reduce energy consumption by 20%.	CO_2	Technology Transfer	Implemented	Saskatchewan Property Management Corporation

Saskatchewan (continued)					
Northern Energy Efficiency Feasibility Study	This study is assessing the potential for pilot projects for improving the energy efficiency of public buildings in Northern Saskatchewan communities.	CO_2	Research	Implemented	Saskatchewan Environment and Resource Management
R-2000 Home	R-2000's goals are to promote energy-efficient housing in Saskatchewan and to provide the framework and procedures whereby builders may construct houses to the R-2000 standard and whereby the houses may receive a national R-2000 identification certificate.	CO_2	Voluntary Information	Implemented	Saskatchewan Homebuilders' Association
Residential Rehabilitation Assistance Program	Program includes several repair programs that benefit low-income homeowners and renters by bringing their homes up to minimum health and safety standards and improving energy efficiency. Also included is a program to encourage landlords to convert appropriate non-residential buildings to residential uses.	CO_2	Voluntary	Implemented	Saskatchewan Municipal Affairs, Culture and Housing
Yukon					
C-2000	Objective is to encourage increased energy efficiency and environmental performance in commercial buildings through enhanced awareness and understanding among building owners and through training courses for building designers and construction contractors.	CO_2	Information Education	Implemented	Yukon Housing Corporation
Commercial Energy Management Program	This program helps communities, First Nations, and private building owners and tenants to implement energy-efficient renovations, energy audits, general information, and financial incentives.	CO_2	Information Education	Implemented	Yukon Housing Corporation
Domestic Hot Water Timer Project	The Domestic Hot Water Timer Pilot Project is an initiative of the Yukon Development Corporation to help determine the compatibility of household hot water consumption use with pre-programmed control timers. The timers will be moved to new residences each year for three years to test their suitability in a total of 150 homes. The pilot project is a trial run for a broader peak reduction program for hot water tanks, which will help to decrease the reliance on diesel generation.	CO_2	Research	Implemented	Yukon Development Corporation

[illegible]	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Yukon (continued)					
EnerGuide for Houses	Provides site visits by energy auditors who test the home to determine its energy rating and consult with occupants on suggested improvements. Also provides low-interest financing to help carry out the energy audit recommendations.	CO_2	Information Voluntary	Implemented	Yukon Housing Corporation
Energy Audit	An energy audit was completed for City of Whitehorse facilities such as office buildings and arenas in 1998. The audit produced information about energy consumption rates and costs. Results of this audit have been used to identify priorities for building maintenance initiatives and retrofits to improve energy consumption and reduce costs.	CO_2	Information	Implemented	The City of Whitehorse
Energy Efficiency Initiative	This initiative promotes the efficient use of energy in the home and in the workplace by providing information to homeowners and businesses. A pilot project involving visits to over 100 homes has been completed. Demonstrations of energy-saving options for businesses are being conducted.	CO_2	Information	Implemented	Yukon Housing Corporation
Energy Management Plan for Government Buildings	The Yukon government is striving to set the example of sound energy management by demonstrating energy-saving systems and by providing a market for energy efficiency products and services. It has developed energy performance standards for Yukon government facilities. An overall energy management plan identifies opportunities to reduce operating costs and GHG emissions.	CO_2	Information	Implemented	Government of Yukon
Green Mortgages	This program encourages energy-efficient construction and the use of local labour and building materials through preferred mortgage rates. Homes must meet a strict energy budget.	CO_2	Economic	Implemented	Yukon Housing Corporation
Home Repair Program	This program is intended to upgrade Yukon homes to current building code standards of safety and comfort. As part of this, it also addresses energy efficiency.	CO_2	Policy	Implemented	Yukon Housing Corporation

Name of Policy/ Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity
Yukon (continued)					
House Calls Energy Efficiency Program	This program promotes energy efficiency and information about climate change to residential consumers.	CO_2	Information	Implemented	Yukon Conservation Society, The Yukon Electricial Compant Ltd., Yukon Energy, Natural Resources Canada
Parking Lot Timer Project	The Parking Lot Timer Pilot Project is an initiative of the Yukon Development Corporation to reduce energy use through the installation of temperature-sensitive parking lot timers. The device triggers at a certain temperature and increases the flow of power to a vehicle as the weather becomes colder. The pilot project has been initiated at six locations in Whitehorse, and data will likely be compiled for three years. This information will be reviewed to examine a broader application of the program to reduce energy use during peak winter hours and decrease the reliance on diesel generation.	CO_2	Research	Implemented	Yukon Development Corporation
R-2000 Home	Promotes low-maintenance, energy-efficient housing through training, builder registration and certification, performance standards, inspections, testing, research and development, and information.	CO_2	Information Education	Implemented	Yukon Housing Corporation
Rental Rehabilitation Program	This program provides low-interest loans to landlords to improve the energy efficiency of rental units.	CO_2	Economic	Implemented	Yukon Housing Corporation
Residential Energy Management Program	This program provides low-interest loans to replace electric heat in residences with alternative heating systems.	CO_2	Economic Technology Transfer	Implemented	Yukon Housing Corporation

Name of Policy/ Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Energy					
Government of Canada					
Accelerated Standards Action Program	This program builds on performance standards that are prescribed under the *Energy Efficiency Act*. The minimum standards are estimated to have accounted for over 10 Mt of annual aggregate emissions reductions in the year 2000.	CO_2	Policy	Implemented	Natural Resources Canada
Advanced Combustion Technologies Program	Program supports the development of pollution abatement and novel combustion technologies aimed at reducing emissions of acid rain precursors, GHGs, particulates, and hazardous substances from stationary power sources fuelled by coal, oil, natural gas, or biomass.	CO_2, CH_4, N_2O	Research	Implemented	Natural Resources Canada
Advanced Materials Technologies Program	Conducts research into innovative materials and processes that respond to environmental requirements and concerns and contribute to climate change mitigation.	CO_2	Research	Implemented	Natural Resources Canada
Asia Pacific Economic Cooperation Energy Working Group	This working group seeks to enhance understanding of policy issues and build the capacity of developing economies to implement energy policies consistent with sustainable development. Expert groups deal with energy efficiency and conservation, "clean" use of fossil fuels, new and renewable energy technology, and energy data and outlook, including CO_2 inventories and indicators.	CO_2	Information Technology Transfer Education	Implemented	Natural Resources Canada
Bio-Fuel Turbine Power Generation Systems	The project consists of the development and testing of systems for engine operation on liquid bio-oil fuel. Bio-oil fuels are derived from feedstock such as wood, grasses, wastepaper, and agricultural residues. The project will further advance the engine technology by redesigning and refining the combustion system and developing specifications for a full-scale power generation system.	CO_2	Research	Implemented	Industry Canada, Orenda Aerospace Corporation
Canada Climate Change Development Fund	The goal of the fund is to contribute to Canada's international objectives in climate change by promoting activities in developing countries that seek to address the causes and effects of climate change while at the same time contributing to sustainable development and poverty reduction. The focus will be on technology transfer and related activities in four programming areas: emission reduction, carbon sequestration, adaptation, and core capacity building for climate change.	CO_2, CH_4, N_2O	Information Technology Transfer	Implemented	Canadian International Development Agency

Name of Policy/ Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Government of Canada (continued)					
Canada Energy Efficiency Project – India	This project builds Indian capacity to promote environmentally sound development through public and corporate policy making and cooperation in the fields of energy efficiency and GHG emissions.	CO_2, CH_4, N_2O	Policy Information Technology Transfer	Implemented	Canadian International Development Agency, Tata Energy Research Institute, International Institute for Sustainable Development
Canada/ European Union Science and Technology Agreement	This broad agreement covers all fields of science and technology including energy and enables Canadian researchers from either the public or private sectors to submit proposals for participation in the European Union's Framework Research and Development programs. The agreement also provides opportunities to participate in basic and applied research in non-nuclear energy.	CO_2, CH_4, N_2O	Information Research	Implemented	Natural Resources Canada
Canada India Rural Energy – India	This project aims to increase the utilization of alternative energy technologies among poor households in India. It also seeks to strengthen the capacity of a network of non-governmental organizations to deliver energy-related activities. An educational component of the project includes the development of curricula related to energy for secondary schools.	CO_2, CH_4	Information Education Technology Transfer	Implemented	Canadian International Development Agency, Partners in Rural Development, The Alternative Energy Network
Chamera Hydroelectric Project – India	This project seeks to upgrade the capacities of the National Hydroelectric Power Corporation to design and construct a hydroelectric dam.	CO_2	Information Technology Transfer	Implemented	Canadian International Development Agency, National Hydroelectric Power Corporation, SNC/Acres Joint Venture
Community Energy Systems	Program helps Canadian communities meet their energy needs by identifying and developing opportunities for the use of district heating and cooling, combined heat and power (co-generation), waste heat recovery, thermal storage, and local sources of renewable energy, particularly biomass.	CO_2	Information	Implemented	Natural Resources Canada
Electricity Energy Efficiency Project – Brazil	Through this project, the Brazilian National Energy Efficiency Program (PROCEL) is building its capacity by drawing on successful Canadian models of demand-side management to change consumer patterns of electricity consumption and to improve efficiencies, in order to slow the expansion of electrical energy consumption.	CO_2	Information	Implemented	Canadian International Development Agency

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Government of Canada (*continued*)					
EnerGuide for Equipment	Program ensures that new major household appliances and room air conditioners comply with the *Energy Efficiency Act* and show a yearly energy consumption rating (major household appliances) or an energy efficiency ratio (air conditioners). All ratings are based on standard test procedures. Labelling helps consumers obtain consistent and reliable information on energy performance.	CO_2	Legislative	Implemented	Natural Resources Canada
Energy Efficient Equipment and Appliances	Regulation aimed at eliminating inefficient energy-using equipment from market by prescribing minimum performance levels.	CO_2	Regulatory	Implemented	Natural Resources Canada
Extension of the Manufacturing and Processing Tax Credit	Tax credit designed to encourage investment in new electrical generating capacity.	CO_2	Economic	Implemented	Department of Finance
Government Purchases of Electricity from Renewable Resources	The federal government will displace its purchases of carbon-intensive sources of electricity with emerging renewable sources. The target under this measure is to purchase 400 000 MWh of electricity annually. The electricity must be generated from a source or the new portion of an expanding generating facility commissioned after April 2001.	CO_2, CH_4, N_2O	Economic Policy	Implemented	Government of Canada
Greenhouse Gas Emission Reduction Trading Pilot	Program is designed to test the effectiveness of emission reduction trading for GHGs in the Canadian context. Buyers and sellers of emissions reductions submit documentation on traded projects to a multistakeholder committee for review. If the emissions reductions satisfy the requirements of the pilot, they are registered and will be eligible for recognition against future compliance obligations.	CO_2, CH_4, N_2O	Economic	Implemented	Government of Canada, Government of Alberta, Government of Nova Scotia, Government of Saskatchewan, Government of Quebec
Green Power Procurement Initiative	This initiative commits to displacing purchases of high-carbon electricity with electricity from emerging renewable sources, referred to as "green power." In addition to reducing GHG and other emissions in federal operations, this initiative provides a demand for green power and encourages electric utilities to market this type of power to other customers.	CO_2, CH_4	Economic	Implemented	Natural Resources Canada, Environment Canada

Government of Canada (continued)					
Hemispheric Energy Initiative	This initiative is the primary vehicle for multilateral energy cooperation and information sharing with Latin America. Initiatives promote information exchange and the identification of areas for future cooperation linked to energy-efficient buildings and equipment, including the development of energy standards.	CO_2	Information	Implemented	Natural Resources Canada
Impact Assessment and Studies of Electrical Distribution Network – Senegal	The studies will help build capacity by determining the best design for high-voltage transmission lines, which will improve the efficiency of the distribution network, thereby reducing GHG emissions.	CO_2	Policy	Implemented	Canadian International Development Agency
Improved Tracking and Reporting of Energy Efficiency and Emissions Trends	This program involves enhancing and extending the industrial portion of the National Energy Use Data Base by better aligning the existing survey instruments administered by Statistics Canada and by increasing the scope and timeliness of their results.	n.a.	Information	Implemented	Natural Resources Canada, Statistics Canada
India Canada Environment Facility – India	This umbrella project seeks to enhance Indian capacity to implement sustainable development activities in the water and energy sector. There are over 15 projects currently under way, a number of which have a climate change component. Includes tree plantations, coastal wetlands, wind energy, and other initiatives.	CO_2	Information	Implemented	Canadian International Development Agency, Canadian High Commission India
International Energy Agency	Emphasizes climate change policy options and their impacts, and develops International Collaborative Research and Development agreements.	CO_2	Policy Research	Implemented	Natural Resources Canada
Kerala State Electricity Board Systems Enhancement Project – India	This project aims to increase the availability of electricity in Kerala State in part through reduction of energy losses in the transmission and distribution systems. It will also build capacity for operating efficiency related to water and energy use management.	CO_2	Information Technology Transfer	Implemented	Canadian International Development Agency, SNC/Lavalin, Kerala State Electricity Board, Thiruvananthapuram, Kerala, Andhra Pradesh State Electricity Boards

Government of Canada (continued)					
Market Incentive Program	The purpose of this program is to provide incentives to electricity retailers to purchase or produce electricity based on emerging renewable electricity sources from new or expanded generating capacity, or to promote the sales of electricity from emerging renewable energy sources.	CO_2	Fiscal	Implemented	Natural Resources Canada
Memorandum of Understanding – Chinese Ministry of Water Resources	Involves cooperation in small hydro power research and development, training of technical personnel, and technology transfer.	CO_2, CH_4, N_2O	Research Technology Transfer	Implemented	Natural Resources Canada
Memorandum of Understanding – Korean Ministry of Commerce, Industry and Energy	Seeks to promote discussion and information exchange and facilitate bilateral cooperation on climate change. The MOU also provides opportunities for joint projects under the Clean Development Mechanism.	CO_2	Information	Implemented	Natural Resources Canada
Memorandum of Understanding – Korean Institute of Energy Research	Provides for cooperation on energy and environmental research and development and on technology transfer.	CO_2	Information Research Technology Transfer	Implemented	Natural Resources Canada
Memorandum of Understanding – Mexican Secretariat of Energy	Provides for cooperation to increase energy efficiency in both countries and encourage use of alternative energy. The memorandum also enhances trade, investment, technical, and other exchanges with respect to energy-efficient products, energy management services, and alternative energy goods and services.	CO_2, CH_4, N_2O	Information	Implemented	Natural Resources Canada
Memorandum of Understanding – United States Department of Energy	Provides for cooperation in research and development in all areas of non-nuclear energy research and development, including energy efficiency in buildings, industry, and transportation, renewables, and cleaner fossil fuels. Cooperation is effected through Implementing Arrangements.	CO_2	Research	Implemented	Natural Resources Canada
Mining and Mineral Science Laboratories	Conducts research in underground mine environment and mine mechanization and automation to reduce energy use in the mining industry.	CO_2	Research	Implemented	Natural Resources Canada

Government of Canada (continued)					
Model Electrical Utility at Jacmel – Haiti	The project is creating the first electrical utility that will operate with low losses in Haiti. This is being achieved mainly through training and development of the electrical utility's staff.	CO_2	Voluntary Technology Transfer	Implemented	Canadian International Development Agency
Model National Energy Code	Aims to increase the energy efficiency of new Canadian houses and buildings by specifying minimum energy requirements. This program supports the implementation and adoption of these model national energy codes by relevant authorities who have jurisdiction for buildings and houses. This program also monitors and analyzes the impact of such codes.	CO_2, CH_4	Regulatory	Implemented	Natural Resources Canada
National Energy Use Database Initiative	This initiative enables monitoring and evaluation of progress toward its goal of limiting GHG emissions, providing information to support the development of future initiatives, and ensuring the development of a base of expertise in the analysis of energy consumption at the end use level.	CO_2, CH_4, N_2O	Information Research	Implemented	Natural Resources Canada
National Fuel-Cell Research and Innovation Initiative	This initiative involves collaborative industrial research, technology development, demonstration, and deployment related to the use of fuel cells for alternative energy production.	CO_2, CH_4, N_2O	Research	Implemented	Natural Resources Canada
Oil and Gas Project Phase II – Bolivia	This project has assisted Bolivia in building the capacity to develop environmental regulations and guidelines and contributed to increases in gas reserves, which will help reduce CO_2 emissions in Bolivia.	CO_2	Information	Implemented	Canadian International Development Agency
Oil and Gas Technology Transfer Programme – China	This project assists in the optimal recovery of China's oil and gas resources by upgrading the capacity of selected petroleum institutions and research centres. Canadian experts were sent to China to conduct specialized courses in various aspects of oil and gas engineering, and selected Chinese experts were sent to Canada for the latest training in oil and gas technology used in Canada.	CO_2, CH_4	Research Information	Implemented	Natural Resources Canada
Petroleum Regulatory Assistance – Peru	This project focuses on strengthening the regulation and monitoring of the hydrocarbon sector. With a better regulatory system for the natural gas sector, the use of this resource will replace current fuels, resulting in lower emissions.	CO_2	Regulatory	Implemented	Canadian International Development Agency, CIPID

[illegible]	[illegible]	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Government of Canada (continued)					
Program of Energy Research and Development	This fund focuses on the economic and environmental impacts of the non-nuclear energy sector. It supports and complements a wide range of energy science and technology initiatives undertaken by 11 federal departments and agencies in Canada. The program supports the development of a range of environmentally and economically sustainable energy production and end use technologies.	CO_2, CH_4, N_2O,	Policy Research Information	Implemented	Natural Resources Canada
Regional Electrical Energy Project – Central America	This project supports the reform of the electrical subsector and enhances regional collaboration in the exchange of electricity. Its activities include increasing efficiencies, reducing losses, introducing demand-side management, helping develop strategies for increased use of hydroelectric resources, and providing support for an initiative to determine the feasibility of importing natural gas into the region. The project builds the capacity of the region to effectively manage its energy resources. The outcome of these initiatives is the reduction of the level of CO_2 emissions.	CO_2	Policy Technology Transfer	Implemented	PREEICA, Canadian International Development Agency
Renewable Energy and Hybrid Systems for Remote Communities	Program accelerates the deployment of renewable energy technologies to more than 300 remote communities that are not connected to the main electricity grid or natural gas networks.	CO_2	Technology Transfer	Implemented	Natural Resources Canada
Renewable Energy Technologies Program	Program supports efforts to develop and commercialize advanced renewable energy technologies that can serve as cost-effective and environmentally responsible alternatives to conventional energy generation. The program supports the development of technologies — including active solar, wind energy, small hydro (less than 20 MW), and biomass.	CO_2	Research	Implemented	Natural Resources Canada
SADC Industrial Energy Management Project	The project is increasing the capacity of consulting engineers, industrial firms, and educational institutions in the SADC region to develop industrial energy management programs, undertake energy efficiency projects, and offer education/training programs in energy conservation and management in Africa.	CO_2	Information Technology Transfer	Implemented	Canadian International Development Agency

Government of Canada (continued)					
Strategic Energy Planning for Southern China	This project transfers appropriate processes and techniques to build capacity in China for developing a comprehensive strategy to provide power and coal for Southern China within an economically, environmentally, and socially sustainable energy management framework.	CO_2, CH_4	Technology Transfer Information	Implemented	Canadian International Development Agency
Support to the Electricity Sector in Bamako – Mali	This project supports and builds capacity for strategic planning activities directed toward improving operational efficiency and maintenance of high-voltage transmission systems of hydroelectricity.	CO_2	Policy	Implemented	Canadian International Development Agency
Tax Incentive for Flare Gas Generation	Made generating equipment fuelled by flare gas at oil fields eligible for a higher capital cost allowance under federal tax regulations. This helps to reduce GHG emissions in the oil and gas industry due to a more controlled combustion process, as well as through the displacement of coal-fired electricity generation.	CO_2	Economic	Implemented	Department of Finance
Tax Incentive for Renewable Energy and Energy Efficiency	Improved access to financing for renewable energy and energy efficiency by relaxing the "specified energy property" rules and expanding the eligibility for flow-through shares to include pre-production costs pertaining to eligible investments in the renewable energy industry. The specified energy property rules were relaxed to allow manufacturing and processing and mining companies undertaking energy efficiency and renewable energy investments to claim the accelerated tax write-offs associated with these investments against income from all sources.	CO_2	Economic	Implemented	Department of Finance
Technology Early Action Measures	Provides funding support for early action technology projects to reduce GHG emissions domestically and internationally, while sustaining economic and social development.	CO_2, CH_4, N_2O, PFCs, SF_6, HFCs	Technology Development and Demonstration	Implemented	Government of Canada
Voluntary Challenge and Registry Inc.	This not-for-profit corporation is dedicated to encouraging private and public sector organizations to voluntarily limit their net GHG emissions by having registered action plans. Federal and provincial governments are represented on the Board of Directors.	CO_2, CH_4, N_2O, PFCs, SF_6, HFCs	Voluntary	Implemented	Voluntary Challenge and Registry Incorporated

Government of Canada (continued)					
WARSEK Rehabilitation Project – Pakistan	This project will assist the Water and Power Development Authority to rehabilitate the WARSEK dam and power station through engineering services, capacity building, and technology transfer.	CO_2	Information	Implemented	Canadian International Development Agency, SNC Lavalin, Water and Power
Alberta					
Geological Sequestration of CO_2 in Alberta Project	This project is assessing the suitability of subsurface for CO_2 sequestration in one of five ways: use in enhanced oil recovery; use in enhanced coal bed methane recovery; storage in depleted oil and gas reservoirs; injection and sequestration in deep saline formations; and storage in salt caverns.	CO_2	Research	Implemented	Development Authority, Department of Resource Development
Improved Coal Combustion Research	An ongoing project to evaluate the combustion, heat transfer, and pollutant characteristics of coal combustion in an enriched oxygen medium with recycled CO_2 from flue gas. Research is aimed at providing a credible database for the development of more energy-efficient fossil-fired power generation cycles, which can produce a purified stream of CO_2 for direct removal from a power plant.	CO_2	Research	Implemented	Department of Resource Development
Injection of CO_2 into Deep Alberta Coal Beds for the Production of Methane	Research is directed toward developing synergies with O_2/CO_2 recycling technology, utilizing the O_2/CO_2 combination furnace to produce a pure CO_2 flue gas that would be captured and used in the coal bed methane technology for the recovery of CH_4. This would result in a zero-emission scenario.	CO_2, CH_4	Research	Implemented	Department of Resource Development
Removal of Barriers to Use of Otherwise Flared Solution Gas	Key priorities have been the creation of a royalty waiver program removing barriers to electricity generation using solution gas that otherwise would be flared.	CO_2, CH_4	Regulatory Voluntary	Implemented	Department of Resource Development, Energy and Utilities Board
British Columbia					
BC Hydro Greenhouse Gas Initiatives	Several initiatives designed to reduce GHG emissions by making 10% of all BC Hydro's new electrical generation resource acquisitions green resources, identifying realistic green energy options, including green energy supplies, new products or services, and new business ventures, and a customer energy efficiency program. BC Hydro is also increasing the energy efficiency of its own operations and facilities.	CO_2	Voluntary	Implemented	BC Hydro

British Columbia (continued)					
Cleaner Power	Purchasing and developing less GHG intensive power. Meeting 10% of new demand with "green energy."	CO_2, CH_4, N_2O	Voluntary	Implemented	BC Hydro
Energy Futures Program	Program identifies realistic green energy options, including green energy supplies, new products or services, and new business ventures. Options being considered are wind, micro-hydro, wood waste, community energy planning, and green energy certification.	CO_2, CH_4, N_2O	Voluntary	Implemented	BC Hydro
GHG Offsets	Buying emissions reductions.	CO_2, CH_4, N_2O	Voluntary	Implemented	BC Hydro
Green Power Procurement and Renewables	BC Hydro is engaged in purchasing power from independent power producers who generate electricity using proven green technologies such as hydro and biomass.	CO_2, CH_4, N_2O, SF_6	Economic Policy	Implemented	Government of British Columbia
Power Smart	Helping customers reduce their electricity consumption through energy efficiency.	CO_2, CH_4, N_2O	Information Economic	Implemented	BC Hydro
Resource Smart	Improving the energy efficiency of the operations and facilities of British Columbia's electrical utility.	CO_2, CH_4, N_2O, SF_6	Voluntary	Implemented	BC Hydro
Renewable Energy Technology	The program provides financial assistance for public education and outreach projects and demonstration projects that test the commercial viability of renewable energy technologies in thermal and electricity generation applications.	n.a.	Technology Development	Implemented	Government of British Columbia
New Brunswick					
Co-generation Policy	A policy to encourage the purchase of electricity by the utility in cases where an industry is modernizing or expanding. The project reduces annual emissions, while opportunities to increase the level of co-generation are continually being sought.	CO_2	Policy	Implemented	Department of Natural Resources and Industry
Energy Efficiency Standards for Equipment	The objective of this program is to improve the energy efficiency of selected products and eliminate the use of inefficient ones. Numerous types of equipment, such as refrigerators, washers, electric motors, and lighting, are regulated for minimum energy efficiency levels.	CO_2	Regulatory	Implemented	Department of Natural Resources and Industry

Northwest Territories					
Energy Conservation Capital Program	Assists territorial and community-funded departments, boards, and agencies, as well as non-profit organizations, by providing grants to support and finance projects that reduce usage of electrical and heat energy and water.	CO_2	Economic	Implemented	Arctic Energy Alliance
Establishment of the Arctic Energy Alliance	The mandate of the Alliance is to help communities, consumers, producers, regulators, and policy makers to work together to reduce the cost and environmental impacts of energy.	CO_2	Information	Implemented	Arctic Energy Alliance NWT Power Corporation, NWT Housing Corporation, NWT Association of Municipalities, NWT Public Utilities Board
The Public Awareness Program	Program provides information about the wise use of energy to all segments of the population.	CO_2	Education Information	Implemented	Arctic Energy Alliance
Nova Scotia					
Energy-Efficient Appliances Act and Regulations	This program sets minimum efficiency levels for energy-using appliances and equipment sold or leased. The act and regulations are intended to increase the energy efficiency of energy-using equipment available in the marketplace and to prevent the dumping of energy-inefficient appliances in the marketplace.	CO_2	Regulatory	Implemented	Nova Scotia Natural Resources
Green Energy and Renewables	Work with utility to establish green power purchase program and increase access for green energy.	CO_2, CH_4, N_2O, SF_6	Policy Economic	Implemented	Government of Nova Scotia, Nova Scotia Power Inc.
Nunavut					
Energy Management	The energy management program promotes energy management and community energy planning with local government, regional staff, and other decision makers, raises awareness, performs energy assessments of major buildings and facilities, and determines the potential for energy management projects that would ensure benefits to the community.	CO_2	Information Education	Implemented	Government of Nunavut
Solarwall Demonstration Project	This passive solar technology preheats air before it is drawn into a building's heating and ventilation system. In order to assess its use in the north, the test project is being conducted on a school in Ranken Inlet.	n.a.	Technology Development and Demonstration	Implemented	Government of Nunavut

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Ontario					
Electricity Sector Reform Egypt – Special Institutional Support Program	This project aims to support reform of the energy sector in Egypt and encourage greater efficiency, through capacity building of local authorities to reduce electricity losses.	CO_2	Information	Implemented	Ontario Hydro, ARA, KPMG
Energy Competition Act	Encourages investment in clean power generation with greatly reduced or negligible GHG emissions. The Act also seeks to create an open electricity market and opportunities for renewable energy sources and high-efficiency generation.	CO_2, CH_4, N_2O	Legislation	Implemented	Ministry of Energy, Science and Technology
Energy Education Program	This program provides information about the environmental benefits of energy efficiency and conservation to teachers and students, allowing them to make informed choices about energy use.	CO_2	Information Education	Implemented	Ministry of Energy, Science and Technology
Energy Efficiency Act and Regulations	The purpose of this program is to prohibit the sale or lease of specified inefficient energy-using appliances or products from the Ontario marketplace by regulation. Performance standards are harmonized with similar requirements in other jurisdictions. Randomly chosen appliances and products are periodically retested to determine compliance with the Act and Regulations.	CO_2	Regulatory	Implemented	Ministry of Energy, Science and Technology
Environmental Information Disclosure	This tool enables electricity retailers to market power supplied from renewable sources. It requires electricity retailers to inform consumers about their generation sources.	CO_2	Information	Implemented	Ministry of Energy, Science and Technology
Legislation Reducing Taxes for Environmentally Friendly Water Power	Encouraging new investment in hydroelectric power stations, which emit negligible amounts of GHGs.	CO_2	Legislation Economic	Implemented	Ministry of Energy, Science and Technology

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Prince Edward Island					
Atlantic Wind Test Site – North Cape	The site facilitates the evaluation, development, and demonstration of wind energy systems and equipment.	CO_2, N_2O	Research	Implemented	Department of Development and Technology
Wind Powered Electrical Generation Facility	Project includes the erection of eight utility grade wind turbines with a nominal capacity of 5.2 MW to annually produce approximately 16 600 MWh of emissions-free electricity.	CO_2, N_2O	Technology	Implemented	Prince Edward Island Energy Corporation, Natural Resources Canada, Maritime Electric
Quebec					
ÉcoGESte Program	The Quebec program to record voluntary action on climate change aims to involve as many people as possible from all areas of activity in taking voluntary action to reduce GHG emissions to their 1990 level.	CO_2, CH_4, N_2O	Voluntary Education	Implemented	Department of the Environment, Department of Natural Resources
Energy Efficiency Agency	This agency has formed partnerships with various organizations to promote energy efficiency. Clients targeted are mainly the industrial and institutional sectors, small- and medium-sized firms, and homeowners.	CO_2, N_2O	Policy Information	Implemented	Department of the Environment
Energy Productivity Program	Program is designed for industries, institutions, municipalities, and agriculture and transportation sectors whose yearly energy bill is greater than $50 000. The program supports feasibility studies and demonstration projects.	CO_2, CH_4, N_2O	Policy	Implemented	Department of Natural Resources
House and Building Regulations	Modified regulations on the energy efficiency of equipment powered by electricity or hydrocarbons to include new equipment. New efficiency requirements for equipment already covered by this regulation have also been introduced. These regulatory changes will have a dual effect, since they will contribute to stabilizing the energy bills of consumers while reducing GHG emissions.	CO_2	Regulatory	Implemented Planned	Energy Efficiency Agency
Support Service for Low-Income Households	The object of this educational activity is to support the efforts made by households to make more efficient use of the energy they consume and thus reduce their energy bills. This is done in partnership with organizations in the community.	CO_2	Information	Implemented	Energy Efficiency Agency

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Quebec (continued)					
Support Service for the Municipal Sector	Provides support for municipal authorities to offer education, training, and awareness raising concerning energy efficiency and the technical implementation of research and development and demonstration projects for the purpose of reducing their energy expenditures and the bills paid by their residents.	CO_2	Information	Implemented	Energy Efficiency Agency
Saskatchewan					
Climate Change Action Plan Initiative	Projects include research and development that have focused on clean coal technology, the capture and storage of CO_2, and terrestrial carbon sequestration.	CO_2	Research Technology Transfer	Implemented	SaskPower
Climate Change Initiative	This initiative searches for new and additional ways to reduce impacts on the environment by improving the energy efficiency of businesses and the public and help them reduce their GHG emissions. These initiatives consist of workshops, natural gas vehicle conversions, residential, industrial, and commercial building energy management programs, and various research and development initiatives.	CO_2	Voluntary Information Economic	Implemented	SaskEnergy
Internal GHG Initiative	This program establishes a commitment to purchase green power from SaskPower for several government buildings and vehicles. Projects include wind farm operation, monitoring and reporting, and market penetration studies.	CO_2, N_2O	Fiscal Economic Policy Technology	Implemented	Government of Saskatchewan, SaskPower
International Test Centre for Carbon Dioxide Capture	This facility will develop technologies to reduce CO_2 emissions, especially those produced by the energy sector.	CO_2	Technology Transfer Research	Implemented	SaskPower, Natural Resources Canada
Weyburn CO_2 Injection Monitoring Project	Program to develop a comprehensive understanding of CO_2 injection into oil-bearing geological structures.	CO_2	Research	Implemented	SaskPower
1-800 Energy Conservation Line	Providing energy efficiency and conservation information to Saskatchewan residents through this toll-free telephone service.	CO_2	Information	Implemented	SaskEnergy

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Yukon					
Energy Awareness Month	This education/awareness campaign is held each year in November. The campaign includes speakers, workshops, and articles in various media.	CO_2	Education Information	Implemented	Government of Yukon
Energy Infrastructure Loans for Resource Development Projects	Program is designed to encourage the responsible and efficient use of energy in the development of resources in the Yukon. It assists Yukon's resource development sector by deferring the high capital cost of building energy infrastructure.	CO_2	Economic	Implemented	Government of Yukon
Energy Solutions Centre	The Canada/Yukon Energy Solutions Centre is a joint initiative led by Yukon Development Corporation and Natural Resources Canada. It provides technical services to facilitate energy solutions for residential, commercial, and government consumers and to improve the delivery and effectiveness of federal and territorial energy programs. It contributes to training and development of Yukon expertise and conducts public awareness and outreach activities relating to energy and climate change.	CO_2	Information	Implemented	Yukon Development Corporation, Natural Resources Canada
Green Power Initiative	This initiative encourages the production of energy from renewable sources in an environmentally sustainable manner. Program seeks to displace diesel electricity production and reduce GHG emissions, especially in communities served only by diesel-generated electrical power.	CO_2	Research Information	Implemented	Government of Yukon
Mayo-Dawson Transmission Project	This initiative will connect the City of Dawson to the Mayo hydro plant to make use of surplus electricity. Connecting Dawson (and residents between Mayo and Dawson) to the grid will eliminate primary dependence on diesel generators. While this project was first considered in 1991–1992, it was only recently that it became economically justifiable. Bids will be reviewed in spring 2001, and the new transmission line should be complete by the end of 2002.	CO_2	Economic	Proposed	Government of Yukon
Renewable Energy Resource Assessment	The Yukon Development Corporation works to identify Yukon's renewable energy resource potential on a comprehensive and systematic basis to assess the value for future supply. This involves assessments, database	CO_2	Economic	Implemented	Government of Yukon

Name of Policy/ Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Yukon (continued)					
	development, mapping renewable hydro potential for wind, geo-thermal, and biomass resources, as well as pilot projects, such as the commissioning of a portable solar/hybrid prototype and investigating hydro feasibility. The Renewable Energy Resource Assessment also monitors and participates in initiatives that impact on land use, such as the Protected Areas Strategy and regional land use planning.	CO_2	Research	Implemented	Yukon Development Corporation
Renewable Power Sales Incentive Program	This program encourages the use of surplus renewable electricity to displace fossil fuels used for space and water heating. The program will guarantee a return on investment to customers who install the equipment necessary to purchase secondary power.	CO_2	Economic	Implemented	Government of Yukon
Rural Electrification Program	This program is available to Yukon residents in areas not serviced by utility power. It encourages the installation of renewable alternative energy systems through information and low-interest loans. Approximately 20 solar energy projects have been completed since the program was introduced in 1998.	CO_2	Research	Implemented	Government of Yukon
Trade Training	The Yukon Housing Corporation in cooperation with Yukon College and other institutions sponsors various courses for tradespeople on energy-related subjects. These courses include heating systems, ventilation systems, and R-2000 technologies.	CO_2	Information Education	Implemented	Yukon Housing Corporation, Yukon College
Wind Power Program	Applied research and development on wind energy. The goal of this program is to overcome the technical barriers (primarily ice accumulation) to commercial-scale wind energy production.	CO_2	Research	Implemented	Government of Yukon
Wind Research and Development Initiative	The Yukon Development Corporation and Yukon Energy Corporation are conducting applied research and development on wind energy on a pilot project basis. Various test sites throughout the Yukon have been monitored over the last five years, and more are in progress through the Community Wind Resource Assessment Program to better determine the viability of the wind regime. Two commercial wind turbines are in production at Haeckel Hill near Whitehorse. The program's goal is to overcome the technical barriers (primarily ice accumulation) and improve the cost-competitiveness of commercial-scale wind energy.	CO_2	Research	Implemented	Yukon College, Yukon Development Corporation, Yukon Energy Corporation

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Forestry					
Government of Canada					
Afforestation Program Development Initiative	Planning and designing afforestation program in Canada, including cost-shared pilots with provinces/territories. This is a preparatory action to carry out program development work that may lead to a larger-scale Phase Two national afforestation program.	CO_2	Policy	Implemented	Natural Resources Canada
Agroforestry Sector Development	Encourage sustainable use of existing timber stands; new stands of fast-growing trees; shelterbelts on cultivated land.	CO_2	Voluntary Education	Implemented	Natural Resources Canada
Asia Regional Fire Danger Ratings System	This project seeks to increase Asian capacity to develop long-term solutions for responding to and monitoring forest fires in the Association of Southeast Asian Nations region.	CO_2	Information	Implemented	Natural Resources Canada
Assessing the Carbon Budget of Circumpolar Forests	This project, a joint initiative with the United Kingdom, Russia, and Scandinavia, involves collaboration to improve our understanding and management of the role of circumpolar boreal forests in the global carbon budget cycle.	CO_2	Information	Implemented	Natural Resources Canada
Boreal Ecosystems Productivity Simulator (BEPS)	BEPS is a remote sensing approach to quantifying the terrestrial carbon cycle. The development of BEPS and its validation and application has been the focus of a government–industry team led by scientists.	CO_2	Research	Implemented	Natural Resources Canada
Broadleaf Forest Development – Honduras	Through this project, sustainable forest management practices are being introduced to reduce deforestation, improve knowledge about protection and harvesting of forests, and manage land use.	CO_2	Information	Implemented	Natural Resources Canada
Chiloe Model Forest Technology Transfer Fund – Chile	Fund supports work with the Chilean Ministry of Agriculture to enhance its capacity to introduce Canada's "model forest" approach in Chiloe.	CO_2	Technology Transfer	Implemented	Canadian International Development Agency

Government of Canada (continued)					
Developing a National Upscaling Strategy for Carbon Budgets of Canada's Forest Ecosystems Using Remote Sensing, Tower Flux, and Inventory Data	This strategy will improve national estimates of how much carbon is stored in Canada's forests. The project will combine the measurement of CO_2 exchanged between the ecosystem and the atmosphere, obtained from tower-based instruments, with satellite information on what types of vegetation are in the forests. The use of satellite imagery will also allow scientists to develop models of the amount of carbon in our forests. This will assist in predicting how forests are responding to climate change.	CO_2	Research Information	Implemented	Natural Resources Canada
Economic Development for Economic Conservation – Costa Rica	This project supports ecological conservation through organic agriculture and appropriate ecotourism initiatives. Through improved conservation of forests, it contributes to reducing GHG concentrations in the atmosphere.	CO_2	Information	Implemented	Canadian International Development Agency
Energy for the Forest	Program funds research relating to biomass energy production. The program seeks to advance the understanding of the role of biomass production in the global carbon cycle.	CO_2	Research	Implemented	Natural Resources Canada
Fire Protection – Adaptation Responses to Climate Change	Project in place, as part of its climate change research program, focused on improving our fire and insect prediction capabilities and devising improved options and strategies to adapt and respond to future fire conditions.	CO_2	Research	Implemented	Natural Resources Canada
Global Observation of Forest Cover	This program aims to improve the quality and availability of satellite observations of forests at regional and global scales and, together with *in situ* observations, produce useful, timely, and validated information.	CO_2	Information	Implemented	Natural Resources Canada
GlobeSAR-2 RADARSAT – South America	This project is assisting in resource management by tracking deforestation and reduction of wetlands. This knowledge will contribute to increased capacity of South American decision makers to sustainably manage their forest resources. This will result in the protection of these important carbon sinks.	CO_2	Information	Implemented	Canadian International Development Agency

		GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Government of Canada (continued)					
Implications of Climate Change for Canada's Forest: Climate Change Research	This program aims to improve Canada's understanding and prediction of the impacts of climate change on our forest ecosystems and develop forest management options and responses for adapting and responding to these impacts.	CO_2	Research	Implemented	Natural Resources Canada
International Institute for Applied Systems Analysis	Collaborates on research related to forest carbon cycles in the Siberian forest and links with research being conducted by the International Boreal Forest Research Association.	CO_2	Research	Implemented	Natural Resources Canada
KALTIM Social Forestry Project – Indonesia	This project seeks to build capacity for the establishment of an approach and methodology for community-based forest management, which will result in a more sustainable management of carbon sinks.	CO_2	Information	Implemented	Canadian International Development Agency
Kunming Horticulture Exposition – China	This project provides support for reforestation and enhanced awareness of the importance of trees for environmentally sustainable development in China.	CO_2	Education	Implemented	Canadian International Development Agency
Old Crow Flats Wetlands Assessment	Environment Canada, in partnership with Laval University, is conducting a retrospective analysis of changes in water cover of the Old Crow Flats. The Old Crow Flats is a Ramsar site (a wetland of international significance). Satellite imagery is being used to track changes in this permafrost-melt landscape. Residents of the aboriginal community of Old Crow have told scientists that the wetlands are drying up due to the changing climate. This Northern Ecosystem Initiative demonstration project is developing methodology that can be applied to other extensive northern wetlands.	CO_2	Research	Implemented	Environment Canada, Laval University
Role of Canada's Forests in the Global Carbon Cycle	This program consists of projects that aim to improve our understanding of carbon storage and release from forests under past, present, and future conditions. The projects also seek to define and evaluate forest management activities that might enhance and sustain storage of atmospheric carbon in forest areas.	CO_2	Research	Implemented	Natural Resources Canada

Government of Canada (continued)					
Sustainable Forest Management – Cameroon	The objective of this project is to support the implementation of Cameroon's sustainable forest management policies through institutional support.	CO_2	Information	Implemented	Canadian International Development Agency
Tree Canada Foundation	The Foundation provides education, technical assistance, resources, and financial support through working partnerships to encourage Canadians to plant and care for trees in urban and rural environments in an effort to help reduce the climate change effects of CO_2 emissions.	CO_2	Policy Information	Implemented	Tree Canada
Tree Growers Cooperative – India	This project seeks to create a sustainable model for village-based community forestry through local capacity building. It will contribute to the protection and enhancement of carbon sinks.	CO_2	Information	Implemented	Canadian International Development Agency
Tree Link – Southeast Asia	This project helps to build the capacity of the region to manage its forest resources. Specifically, it supports the development and implementation of policies and practices for forest renewal, conservation, and protection.	CO_2	Information	Implemented	Canadian International Development Agency
Zambezi Wetlands Conservation – South Africa	The primary objective of this project is conservation and sustainable use of the Zambezi wetlands. This will be accomplished through information dissemination to decision makers, which will help build their capacity to manage these wetlands. A by-product of such action is the preservation of a carbon sink.	CO_2	Information	Implemented	Canadian International Development Agency
Alberta					
Build Awareness to Determine Best Forest Management Practices in Relation to Sinks	Work with private landowners (especially those with agricultural activities) to ensure that they have sufficient knowledge, from both an afforestation and an agricultural activity perspective, to make informed decisions about which programs to undertake. This type of program would be built in partnership with those in the sector with appropriate experience.	CO_2	Information Education	Implemented	Alberta Environment
Foothills Model Forest/ Sustainable Forest Management Network	Supports research into the carbon dynamics of forests and other landscapes of the boreal forest. The Foothills Model Forest has compared the impact of wildfire disturbance and wood products manufacture on the sequestering of carbon. In the last two years, the Network investigated the size and	CO_2	Research	Implemented	Alberta Environment

Alberta (continued)					
	dynamics of some of Alberta's largest carbon pools, such as peatlands. During the next few years, the Network plans to investigate the accuracy of measurement of carbon fluxes in Alberta's forest landscapes.				
British Columbia					
Afforestation Initiative – Regional Pilot	A two-phase development/implementation program to afforest privately owned marginal agricultural land, to be developed as a public/private partnership and in cooperation with the federal government.	CO_2	Voluntary	Implemented	Ministry of Forests
Carbon Budget Modelling	Program analyzes carbon emissions for tree farm licences and timber supply areas under combinations of potential accounting rule scenarios.	CO_2	Research	Implemented	Ministry of Forests
Ethanol Production from Wood Waste	The objective of the initiative is to facilitate the establishment of a new technology approach to ethanol production from wood waste.	CO_2	Research	Implemented	Ministry of Employment and Investment, B.C. Trade and Investment Office
Fire Management Technology Transfer Project – Argentina	Project is working with the Argentinean National Fire Management Organization to develop a national infrastructure for the prevention and management of forest fires in Argentina.	CO_2	Technology Transfer	Implemented	Ministry of Forests
Research and Modelling Towards Developing a Carbon Management Accounting Framework	Development of a carbon management accounting framework for forests that focuses on four key areas: developing standards for carbon measuring, reporting, and monitoring for the province with links to national standards; investigating the development of a carbon information system, enabling forest companies to submit operational data for automatic processing/reporting; researching soil carbon storage to develop regionally specific conversion factors relating merchantable volume to estimates of soil carbon storage; and investigating legislative changes required to establish non-timber rights to sequestration credits as an incentive to forest carbon sink projects.	CO_2	Research Information	Implemented	Ministry of Forests
New Brunswick					
Afforestation and Reforest-ation Initiative	An afforestation component of its private land silviculture program that is planting trees on abandoned, privately owned farmland.	CO_2	Voluntary	Implemented	Government of New Brunswick

Nova Scotia					
Forestry Projects to Improve Knowledge of Carbon Sinks	Intensification of forest sample plots to measure growing stock and growth rates, resulting in increased carbon storage in forests.	CO_2	Information Education	Implemented	Nova Scotia Natural Resources
New Forestry Regulation and Requirements to Increase Level of Structure	Increase forest growth through prompt regeneration; compel wood buyers to finance silviculture on lands of origin.	CO_2	Regulatory	Implemented	Nova Scotia Natural Resources
Ontario					
Improved Forest Management and Wood Harvesting Methods	Methods introduced to protect healthy forest growth and minimize damage in order to increase the natural GHG absorption potential in forests.	CO_2	Policy	Implemented	Ministry of Natural Resources
Wetlands Program	Program aim is to conserve and restore wetlands and prohibit development on significant wetlands, thereby increasing the significant GHG absorption potential in wetlands.	CO_2	Policy	Implemented	Ministry of Natural Resources
Saskatchewan					
A Framework for Assessing Climate Change Adaptation Options for the Forestry Sector in the Prairie Provinces	This project will develop a framework for identifying ways in which forest companies can adapt to climate change impacts.	CO_2	Research Information	Implemented	Prairie Adaptation Research Cooperative, University of Saskatchewan, Saskatchewan Environment and Resource Management, Research Council of the University of Saskatchewan
Saskatchewan Carbon Sequestration Agreement	This program involves silviculture activities, including the planting of approximately 5 million trees and the establishment of a Forest Carbon Reserve. The transfer of GHG emission reduction credits is equal to the amount of the sequestration from the silviculture activities.	CO_2	Economic	Implemented	SaskPower
Vulnerability of the Western Canadian Boreal Forest to Climate Change	This project will determine the vulnerability of the western boreal forest to climate change in terms of insect/disease outbreaks, frequency and intensity of forest fires, and impacts of moisture stress.	CO_2	Research	Implemented	Government of Saskatchewan, Natural Resources Canada

Industry					
Government of Canada					
Advanced Combustion Technologies Program	The program supports the development of pollution abatement and novel combustion technologies aimed at reducing emissions of acid rain precursors, GHGs, particulates, and hazardous substances from stationary power sources fuelled by coal, oil, natural gas, or biomass.	CO_2	Research	Implemented	Natural Resources Canada
Advanced Energy Technologies for High Temperature Processes Program	Focus is on coke-making and pulverized coal injection on behalf of coal and steel producers. Activities include improving the energy efficiency of the iron-making process, supercoke, extending coke oven life, mineral additions to improve coke quality, and pulverized coal injections. Computer modelling capabilities for blast furnace optimization are also developed.	CO_2	Research	Implemented	Natural Resources Canada
Advanced Materials Technologies Program	The program conducts research into innovative materials and processes that are critical to the competitiveness of industry and vital to respond to new environmental requirements and concerns and to contribute to climate change mitigation. Research areas include lightweight materials for transportation applications and advanced metallic powders for rechargeable batteries.	CO_2	Research	Implemented	Natural Resources Canada
Advanced Separation Technologies	Conducts fundamental and applied research to develop and implement leading-edge separation technologies for the petroleum and environmental industries. Focus is to find solutions for industrial science and technology problems. This approach is based on a fundamental understanding of the principles governing industrial processes and is enhanced by strategic partnerships and collaborative initiatives with industry, educational institutions, governments, and the scientific community. Program activities can provide reduced operating and energy costs and reduce GHG emissions.	CO_2	Research	Implemented	Natural Resources Canada
Bio-Fuel Turbine Power Generation Systems	The project consists of the development and testing of systems for engine operation on liquid bio-oil fuel. Bio-oil fuels are derived from feedstock such as wood, grasses, wastepaper, and agricultural residues. The project will further advance engine technology by redesigning and refining the combustion system and developing specifications for a full-scale power generation system.	CO_2	Research	Planned	Industry Canada

Government of Canada (continued)					
Boiler Emission Upgrade – India	This project aims to increase the capacity of Indian stakeholders through increased awareness of and means to introduce viable technology to revamp old and failing power plants using circulating fluidized bed technology.	CO_2	Voluntary Information	Implemented	Canadian International Development Agency, Benegal Engineering College, National Power Training Institute, West Benegal State Electricity Board, Greenfield Research Inc, Dalhousie University
Canada China Cooperation Project in Cleaner Production – China	In this project, emphasis is placed on pollution prevention, conservation of raw materials and energy, and eliminating use of toxic raw materials by strengthening institutional capacity to implement cleaner production. In collaboration with China's State Economic and Trade Commission and national Environmental Protection Agency, the project will strengthen the institutional capacity of these institutions to promote the implementation of cleaner production techniques.	CO_2	Policy	Implemented	Canadian International Development Agency, Coopers & Lybrand, SNC Lavalin Environment, Essa Technology, State Economic and Trade Commission, State Environmental Protection Agency
Canada-China Jiangsu SME Applied Management and Environment Project – China	This project seeks to build management and environmental/ business capacity for small and medium-sized enterprises through increasing awareness and demonstration projects around waste minimization, cleaner production, etc. The project will also support sectoral linkages and information exchange between Canadian industries and Jiangsu village enterprises in the focus sectors of the project, initially chemical and metal working industries.	CO_2	Education Information	Implemented	Canadian International Development Agency, Foundation for International Training, MOFTEC and Jiangsu COFTEC, EPB and Bureau of TVEs
Canadian Industry Program for Energy Conservation (CIPEC)	The Canadian Industry Program for Energy Conservation (CIPEC) helps industrial task forces set and achieve targets for improving energy intensity in their sectors. CIPEC's 21 voluntary sector task forces determine the potential for energy efficiency improvements within their sector, establish a means of reporting and tracking progress, and create action plans for reaching targets. They also provide a forum for identifying common needs in such areas as energy management planning, technical information, financing, training, and employee awareness. The Office of Energy Efficiency of Natural Resources Canada then works with the task forces to develop appropriate services to satisfy these needs.	See below	Voluntary	Implemented	Natural Resources Canada

Government of Canada (continued)					
CIPEC: Aluminum	Voluntary targets to improve energy efficiency in the aluminum sector. Significant improvements will come from the construction of new, state-of-the-art smelters and the phasing out of older facilities. Seventy percent of the total aluminum production currently comes from modern facilities, and developing effective economic models for the continued introduction and funding of new facilities remains a significant industry challenge. The expansion of aluminum recycling is also a sectoral priority. Aluminum is fully recyclable, and reforming scrap into useful metal requires only 5% of the energy consumed in the production of primarily aluminum.	CF_4, C_2F_6, CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Brewery	Voluntary targets to improve energy efficiency in the brewery sector. Enhanced metering, monitoring, and control have enabled many breweries to improve the energy usage performance of boilers and CO_2, air distribution, pasteurizer, condensate, and stream-handling systems. Procedural changes have been supported by the establishment of in-plant energy committees and employee education and training programs, in many cases employing NRCan's energy awareness kits and active communication efforts. Within the industry, companies are expanding energy awareness education and encouraging employees to participate in energy management workshops.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Cement	Voluntary targets to improve energy efficiency in the cement sector. Cement manufacturers are looking to the use of waste materials as an economical source of fuel. The industry continues to promote concrete as an energy-efficient product and to make cement and concrete the materials of choice in the environmental industry. It is also working to develop an appropriate methodology for the life cycle assessment of cement-based materials and products. Cement, in the form of concrete, has a number of energy-saving advantages.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Chemical	Voluntary targets to improve energy efficiency in the chemical sector. While all industry subsectors report significant energy efficiency gains, there are substantial variations in energy consumption patterns. Nearly all industry subsectors are meeting their energy intensity performance targets, matching, and in some cases substantially improving on, benchmark 1990 levels. Contributing to the sector's performance is the installation of co-generation facilities, which results in the more efficient use of hydrocarbon fuels to generate heat and electricity.	CO_2	Voluntary	Implemented	Natural Resources Canada

Government of Canada (continued)					
CIPEC: Dairy	Voluntary targets to improve energy efficiency in the dairy sector. The National Dairy Council of Canada continues to encourage industry-wide participation in energy conservation efforts. Each product subsector is encouraged to implement its own comprehensive set of low-cost, no-cost, and retrofit improvement in dozens of plant operations. These include thermal storage of recovered hot water, exterior tanker recycled water washes, and improved control of air and water leakage. Information on expected cost savings and payback periods is provided to companies seeking to make such improvements. The industry supports the energy efficiency achievements of dairy plant managers through research and educational materials. The industry is also profiling and evaluating new energy-saving technologies. Such concepts include expert control systems, non-thermal pasteurization systems, pulsed drying systems, and just-in-time dairy manufacturing concepts. Training is available to help energy managers measure energy efficiency and to direct them to global studies on successful dairy product energy management strategies and practices.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Electric and Electronic	Voluntary targets to improve energy efficiency in the electric and electronic sector. While the electric and electronics industry is Canada's least energy-intensive manufacturing sector, individual companies continue to include energy efficiency as a vital component in their efforts to control costs. Between 1990 and 1997, the sector's energy consumption dropped 11% despite a substantial growth in production. Combined, these trends have resulted in a decrease in energy intensity of almost 50%.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Fertilizer	Voluntary targets to improve energy efficiency in the fertilizer sector. Canadian fertilizer manufacturers are constantly improving production methods, reducing emissions, and increasing energy efficiency. Their efforts have made Canada an acknowledged world leader in energy efficiency and the control of emissions from its fertilizer production facilities. Producing nitrogen and potash fertilizers is energy-intensive, making energy conservation and efficiency a key industry priority.	CO_2, N_2O	Voluntary	Implemented	Natural Resources Canada

Government of Canada (continued)					
CIPEC: Food	Voluntary targets to improve energy efficiency in the food sector. Companies continue to invest in energy efficiency. The installation of energy-efficient air pressure blanket doors and air reclaimers as well as the modernization of equipment and facilities have helped to improve energy efficiency. Food processors have also actively pursued fuel switching. Companies are changing from carbon-intensive fuels such as oil to natural gas. Since 1990, electricity use has remained stable, while steam use has increased and heavy fuel oil use has declined.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Foundry	Voluntary targets to improve energy efficiency in the foundry sector. Most of Canada's foundries continue to seek ways to improve their energy efficiency and reduce GHG emissions. Many firms, for example, no longer use GHG-generating fuels such as coal, oil, or coke in their operations. Many have also eliminated the use of steam produced by coal-generated electricity. The potential cost savings resulting from energy efficiency improvements made by the foundry industry are estimated to be in the range of $9 million per year.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: General Manufacturing	Voluntary targets to improve energy efficiency in the general manufacturing sector. The sector is represented by an energy conservation task force made up of 14 leading companies in a variety of industries, including construction materials, floor coverings, imaging products, insulation, and adhesives, among many others.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Lime	Voluntary targets to improve energy efficiency in the lime sector. Canada's commercial lime producers, represented by the Canadian Lime Institute, are active participants in an ongoing effort to reduce the energy component in their products. Merchant lime producers operate from 15 producing sites staffed by 650 employees. Natural gas is the principal fuel used, with coke and coal making up most of the balance.	CO_2	Voluntary	Implemented	Natural Resources Canada

Government of Canada (continued)					
CIPEC: Mining	Voluntary targets to improve energy efficiency in the mining sector. The mining industry's energy mix is heavily weighted toward electricity, at 44% of the total energy demand. Heavy fuel oil and distillates satisfy most of the remaining energy requirements. An active program of fuel switching in the industry has led to substantial reductions in the use of coal.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Oil Sands	Voluntary targets to improve energy efficiency in the oil sands sector. The industry continues to implement measures that deliver on its commitment to reduce energy intensity and increase efficiency. Improvements are coming through a combination of operational excellence and technological innovation. Plants have improved the reliability of their operations and introduced programs to recover waste heat and improve yields through more efficient processing. Additional gains realized by introducing new technologies in the mining and extraction stages. The industry's principal focus is to reduce the use of coke by switching to natural gas.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Petroleum Products	Voluntary targets to improve energy efficiency in the petroleum products sector. The demand for petroleum products is expected to increase in step with population and economic growth, putting pressure on the industry to increase its use of energy. While the industry continues to exceed its commitment of a 1% annual improvement in energy intensity, pressures for increased production will make ongoing improvements more challenging. Fortunately, higher capacity utilization improves refinery efficiency, thereby lowering the energy required per unit of output. The industry also faces increasing pressure to reduce the sulphur levels in gasoline. Meeting increasingly stringent sulphur content requirements will require refineries to employ more energy-intensive methods.	CO_2	Voluntary	Implemented	Natural Resources Canada

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Government of Canada (continued)					
CIPEC: Pulp and Paper	Voluntary targets to improve energy efficiency in the pulp and paper sector. In 1997, the Canadian Pulp & Paper Association commissioned a study to explore the expanded use of surplus wood residue as a fuel for pulp and paper production. The association remains active on several committees involved in the climate change consultative process. At the mill level, companies continue to introduce energy intensity improvements and have implemented programs to switch from fossil fuels to biomass.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Rubber	Voluntary targets to improve energy efficiency in the rubber sector. As the industry's principal voice, the Rubber Association of Canada plays a crucial role in environmental issues. The association is working with local authorities to establish provincial scrap tire stewardship boards. It also sponsors a biannual international symposium on rubber recycling as a means of encouraging the commercial development of this fragile, emerging industry. The association has established and maintains an industry-wide environmental tracking grid to measure the overall performance of the rubber manufacturing sector industry. All of these activities have energy consumption and air quality implications. By focusing the industry's attention on environmental issues, the association is playing a critical role in the long-term move toward improved energy intensity and reduced GHG emissions.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Soft Drink	Voluntary targets to improve energy efficiency in the soft drink sector. The soft drink sector takes a broad perspective on the energy consumed to bring its products to market. This approach has led the industry to adopt alternative packaging strategies that are more environment-friendly, as well as less energy-intensive.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Steel	Voluntary targets to improve energy efficiency in the steel sector. The industry has made excellent progress in reducing its energy intensity and is making a solid contribution to GHG reductions.	CO_2	Voluntary	Implemented	Natural Resources Canada

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Government of Canada (continued)					
CIPEC: Transportation	Voluntary targets to improve energy efficiency in the transportation manufacturing sector. Canada's automotive industry is committed to continuously improving quality environmental performance and energy efficiency. Energy-efficient equipment is installed where feasible, but downsizing and internal competition for funds are challenging energy managers who are seeking to make major gains. Environmental issues, now a major component in corporate planning, have led to the implementation of costly technologies that improve the environment and friendliness of the industry's products and reduce emissions at the cost of increased energy use. This adds to the challenge of reducing energy consumption.	CO_2	Voluntary	Implemented	Natural Resources Canada
CIPEC: Wood Products	Voluntary targets to improve energy efficiency in the wood products sector. The wood products industry has made significant progress in efforts to switch to biomass fuels. Wood waste, which provided 50 245 TJ of energy in 1995, supplied 69 097 TJ in 1997, an increase of 38%. Biomass, which represented 45% of total energy used in 1995, now makes up nearly 55% of total energy consumed. Individual companies in the industry continue to implement low-cost energy efficiency measures whenever possible. However, the sector's production and energy efficiency continue to be adversely affected by economic factors. Companies have increased their focus on product improvement and marketing, efforts that have forced a change in their product mix and led to greater energy consumption.	CO_2	Voluntary	Implemented	Natural Resources Canada
Canadian Lightweight Materials Research Initiative	Initiative works to strengthen and coordinate research and development for lightweight and high-strength materials for vehicle applications. It addresses fundamental materials issues in alloy design and thermo mechanical processing and in manufacturing processing, to improve the performance or reduce the cost of implementing lightweight materials to reduce vehicle weight in order to achieve greater energy efficiency. The technologies developed can also significantly improve the performance of vehicles powered by fuel cells, electric batteries, or hybrid systems. The materials considered include manganese, aluminum, high-strength steel, metal matrix composites, plastics, and polymer-based composites.	CO_2	Research	Implemented	Natural Resources Canada

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Government of Canada (continued)					
Canadian Environmental Technology Advancement Centres	To help meet the needs of Canada's growing environmental industry, the federal government has supported the establishment of centres, in partnership with provincial governments, environmental industry associations, and the private sector. The centres are private sector, not-for-profit corporations, operating at arm's length from government. Each centre's goal is to help small- and medium-sized enterprises commercialize environmental technologies by providing comprehensive technical services, access to investment capital, business counselling, and regulatory and market analysis.	CO_2	Information Fiscal	Implemented	Environment Canada
Capital Cost Allowance and Related Changes	Encourages investment in certain types of energy-efficient and renewable energy technologies.	CO_2, CH_4, N_2O	Economic	Implemented	Department of Finance
Centre for Research in Cleaner Manufacturing	Develops scientific and engineering platforms for evaluating and guiding innovation in clean, commercially viable technologies and production processes, including those that help reduce GHG emissions.	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Policy	Implemented	National Research Council Canada
Confederation of Indian Industry Environmental Management Programme	This project is designed to improve the capacity of the Confederation of Indian Industry's Environmental Management Division to participate in, raise awareness of, and promote cooperation in the development of environmental policies for industry.	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Policy Information	Implemented	Canadian International Development Agency, Vaughan/Roche EVS
Energy Benchmarking Strategy	Project provides tools to measure and compare energy performance (usage and costs) in underground bulk mining operations, in order to identify where improvements and better practices can be adopted. The project consists of the development and demonstration of a cost-effective process for the production of ethanol from a wide variety of biomass, including farm waste products such as straw and oat hulls.	CO_2	Information	Implemented	Mining Association of Canada

Government of Canada (continued)					
Environmental Technology Verification Program	Designed to foster the growth and marketability of the environmental industry by providing validation and independent verification of performance claims. This initiative will promote the environmental industry internationally while building sustainable industry capacity at home. A key component of the program is that it will enable innovative environmental technologies to access markets more effectively. Verification is seen as an important tool for accelerating the application of innovative technologies and creating new business opportunities and jobs, while also protecting the environment.	CO_2	Policy Technology Transfer	Implemented	Environment Canada
Ethanol from Biomass	The project consists of the development and demonstration of a cost-effective process for the production of ethanol from a wide variety of biomass, including farm waste products such as straw and oat hulls.	CO_2, NO_x	Research	Planned	Industry Canada
Gas Separation Technology for the Industrial Oxygen and Fuel Cell Markets	The project consists of the development of a unique gas separation technology that strips nitrogen and other gases from an air stream, leaving pure oxygen. This technology will allow oxygen separation to occur over 200 times faster than traditional systems, resulting in smaller industrial oxygen plants. The company is also exploring the use of the technology to increase the efficiency of fuel cells in automotive applications.	CO_2	Research	Planned	Industry Canada
Global Climate Change: Taking Action	This project supported the Pembina Institute's and Stratos's collaboration on the creation of a guide to help managers at all levels in the Canadian mining industry develop a corporate strategic response to the risks and opportunities associated with climate change and GHG emission reductions. The guide includes the rationale for progressive action on climate change, GHG emissions reduction opportunities, and business opportunities related to GHG emissions reductions that can be implemented in mining operations both within and outside Canada. The guide also includes information on how to inventory, measure, and report on climate change actions.	CO_2	Information	Implemented	Mining Association of Canada

Government of Canada (continued)					
Industrial Drying Technologies Program	The program aims at improving the energy intensity of the existing dryer base and of drying technologies to upgrade residues. The program focuses on improving the existing dryer base; the commercialization of the pulse fluid bed and the jet-spouted-bed dryers in the agri-food industry; the development and commercialization of intelligent control systems for dispersion-type dryers; the assessment of the opportunity for advanced controls in the drying industry; and the assessment of the potential of new residue upgrading technologies.	CO_2	Research Policy	Implemented	Natural Resources Canada
Industrial Energy Efficiency Initiative	The Industrial Energy Efficiency Initiative is a voluntary industry-government alliance that recognizes that improving energy efficiency can help Canadian industry stay competitive and help protect the environment. Also assists the manufacturing and metal/non-metal mining industries identify energy efficiency potential, establish energy efficiency improvement targets, implement and manage programs, report on progress, and celebrate accomplishments.	CO_2	Voluntary	Implemented	Natural Resources Canada
Industrial Energy Innovators Initiative	Once the CIPEC task forces have drafted targets and action plans, the Industrial Energy Innovators Initiative provides a means for turning sector commitments into company actions. Projects begin with CEOs and other senior officials committing to implement energy-saving measures in their organizations. When this commitment has been assured, the Industrial Energy Innovators Initiative provides the information and support services necessary to starting an upgrade.	CO_2	Voluntary Policy	Implemented	Natural Resources Canada
Industrial Process Integration	The Industrial Process Integration program supports the development and deployment of process integration in various industries. The program focuses on water network optimization methodologies in the agri-food, pulp and paper, and textile industries; combined heat and power optimization methodologies; total site optimization methodologies; and the building of an international-calibre Canadian capacity in process integration.	CO_2	Information	Implemented	Natural Resources Canada

Government of Canada (continued)					
Industrial Research Assistance Program	The Industrial Research Assistance Program (IRAP) helps Canadian companies identify and adopt technology solutions from a wide range of domestic and foreign sources. Technical advice and personal business consultations are available through a network of more than 250 IRAP advisors in 90 communities across Canada.	CO_2, CH_4, N_2O, HFCs	Policy Research	Implemented	National Research Council of Canada
Industry Energy Research and Development	The Industry Energy Research and Development program supports the development and use of energy-efficient processes, products, systems, and equipment by industry. Projects contribute to a cleaner environment and help Canadian companies increase their market competitiveness. Work is conducted with all Canadian industrial sectors. The cost of technology development is shared with industry and other project participants.	CO_2	Research	Implemented	Natural Resources Canada
Industry Heat Management Research Program	The purpose of this program is to develop and disseminate knowledge and technology that will (1) contribute to a reduction in GHG and other emissions in Canada through improvements in industrial energy efficiency, and (2) contribute to jobs and wealth creation through improvements in industrial productivity and competitiveness, and by helping the Canadian energy efficiency industry capture growing domestic and international markets. The delivery mechanism for the program is collaborative in-house research involving manufacturers, service providers, and end users.	CO_2	Research	Implemented	Natural Resources Canada
International Centre for Sustainable Development of Cement and Concrete	International Centre for Sustainable Development of Cement and Concrete conducts research activities, demonstration projects, transfer of technology, and networking for the sustainable development of cement and concrete. The objective of this program is to optimize the use of supplementary cementing materials (such as fly ash, slag, silica fume), recycled materials, and other industrial by-products in concrete for every particular application in full compliance with performance requirements.	CO_2	Research	Implemented	Natural Resources Canada

Government of Canada (continued)					
Mining Research	Through research programs on underground mine environments and mine mechanization and automation, Natural Resources Canada's Mining and Mineral Sciences Laboratories contribute to reduced energy consumption in the mining industry. Supplying the necessary air, temperature, light, and space requirements for workers underground is very energy-intensive. Through automated ventilation management and mine mechanization, these requirements can be substantially reduced, increasing overall efficiency and reducing energy needs in mining. For example, the mining laboratories have established a North American consortium to replace diesel with hydrogen fuel cells in underground production vehicles. This will have a significant impact on operations.	CO_2	Research	Implemented	Natural Resources Canada
Model Voluntary Agreements	Model voluntary emissions reduction agreements with binding targets.	CO_2	Voluntary	Implemented	Environment Canada
National Action Plan on Ozone Depleting Substances and their Halo-Carbon Alternatives	Regulations controlling the use of ozone-depleting substances are in place in all jurisdictions; in addition, Alberta, British Columbia, Newfoundland, Ontario, Yukon, and the federal government regulate the use of HFCs.	HFCs, PFCs	Regulatory	Implemented	Environment Canada
National Centre for Upgrading Technology	A heavy oil upgrading research alliance, which provides independent research and technical services. The centre's upgrading research and services play a vital role in the development of the heavy oil industry. Upgrading is the necessary step in changing oil sands bitumen from a black tar substance into a simulated conventional crude oil. Oil refineries can then process this changed bitumen into products such as transportation fuels. Projects can help reduce operating and energy costs and reduce GHG emissions.	CO_2	Research	Implemented	Natural Resources Canada

Government of Canada (continued)					
National Fuel Cell Research and Innovation Initiative and Facility	Facility will be established at the National Research Council of Canada's Innovation Centre in Vancouver. The facility will support a research and technology demonstration and deployment program. As well, a university research fund will be established to build on work being done by the National Research Council and the Natural Sciences and Engineering Research Council.	CO_2	Research	Planned	National Research Council of Canada, Natural Resources Canada, Natural Sciences and Engineering Research Council
Petroleum Technology Research Centre	A new agency in Saskatchewan that will coordinate and promote petroleum-related research. It will coordinate work at the university's newly created Petroleum Engineering Group and the Saskatchewan Research Council's Petroleum Division. It will also act as a mechanism to transfer information on oil and gas production technology to the industry in the province.	CO_2	Research	Implemented	Natural Resources Canada
Processing and Environmental Catalysis Program	Focuses on the development of environmentally sound and economically viable technologies for the production of alternative and renewable transportation fuels, fuel additives, and petrochemicals from natural gas, light hydrocarbons, and renewable sources. Advanced catalytic systems are also being developed.	CO_2	Research	Implemented	Natural Resources Canada
Renewable Energy and Hybrid Systems Program	Program focuses on the development, implementation, and promotion of photovoltaic technologies for domestic and international markets.	CO_2	Research	Implemented	Natural Resources Canada
Renewable Energy Market Development Program	Program encourages the use of renewable energy from emerging resources and helps the supply industry take advantage of promising markets. The program also helps industry improve its delivery infrastructure through a variety of activities, including upgrading industry training programs and product standards and developing software to facilitate feasibility studies and system designs.	CO_2	Information	Implemented	Natural Resources Canada

Government of Canada (continued)					
Voluntary Challenge and Registry Inc.	This is a not-for-profit corporation that encourages private and public sector organizations to voluntarily limit their net GHG emissions as a step toward meeting Canada's climate change goals. To date, more than 700 companies and organizations from all sectors of the economy have registered action plans, including the Government of Canada and all provincial governments.	CO_2	Information	Implemented	Natural Resources Canada
Alberta					
Control of HFCs and PFCs	Amendments to Alberta ozone-depleting substances regulation to control releases of HFCs, PFCs, and HCFCs.	CO_2	Regulatory	Implemented	Government of Alberta
Energy and GHG Emissions Reductions Pilot Project	Energy audit pilot projects a savings in energy costs and GHG emissions reduction. Enhance awareness of GHG-reducing management practices.	CO_2	Information	Implemented	Alberta Food Processors Association
GHG Monitoring and Reporting Pilot	Begin industry reporting of GHG emissions.	n.a.	Information Research Voluntary	Implemented	Government of Alberta
Industry Workshops on International Actions	The Alberta government is sponsoring a series of one-day workshops highlighting important developments in international climate change negotiations. These workshops provide Alberta industry with information on how it can benefit from and become involved in international projects. The initial focus is on companies already doing business in Latin America. Company and government representatives from Alberta and Latin American countries are invited to a two-day conference to explore opportunities to increase awareness of Clean Development Mechanism projects in Latin America.	CO_2	Education	Implemented	Government of Alberta

Alberta (continued)					
Reductions in Flaring	Alberta's Energy and Utilities Board has incorporated a 25% reduction on volumes flared by 2001 and stringent performance standards for the remaining flares.	CO_2	Policy	Implemented	Alberta Energy and Utilities Board
Removal of Barriers to Use of Otherwise Flared Solution Gas	These actions have been taken to facilitate electricity generation from solution gas that would otherwise have been flared. Key priorities have been the creation of a royalty waiver program announced in July 1999 that exempts otherwise flared solution gas from the *Electric Utilities Act*.	CO_2	Policy Economic	Implemented	Alberta Resource Development, Alberta Energy and Utilities Board
Support for Engaging Small- and Medium-Sized Enterprises	Engage small- and medium-sized enterprises to take action on climate change in Alberta. This will result in improved energy efficiency and at the same time improve the competitiveness of Alberta companies.	CO_2	Information Education Fiscal	Implemented	Pembina Institute, Government of Alberta
British Columbia					
Fuel Cell Initiative	The British Columbia government is working with the federal government, the Greater Vancouver Regional District, and university and industry representatives on a proposal to set up a national partnership that would spawn a fuel cell industry in British Columbia. The partnership would focus on establishing a national research centre on fuel cells in B.C. and testing fuel cells in stationary sites.	CO_2	Research	Adopted	Information, Science and Technology Agency
Oil and Gas Commission Environmental Fund	The oil and gas industry, through an agreement with the Government of British Columbia, established a $5 million environmental fund over five years to be administered by the Oil and Gas Commission. The fund is intended to support research related to environmental issues associated with oil and gas operations, including GHG emissions.	n.a.	Research Information	Implemented	Government of British Columbia, Oil and Gas Commission
Northwest Territories					
Integration of Climate Change in Environmental Assessments	Ensure integration of climate change considerations during the Environmental Assessment Process for all new projects.	CO_2	Policy	Adopted	Government of Northwest Territories

Nova Scotia					
Encourage Use of Natural Gas in Nova Scotia	Maintain a regulatory framework that encourages the use of natural gas and ensure that industry locates where appropriate infrastructure is already in place.	CO_2	Policy Regulatory	Implemented	Nova Scotia Natural Resources
Light Better for Less	This program improves lighting efficiency in small commercial operations. Electrical contractors are trained to perform lighting energy audits on small commercial facilities and recommend and install energy-efficient lighting. Wholesalers are asked to increase stock of lighting projects. Seminars and other marketing are directed at small commercial operators.	CO_2	Information	Implemented	Illuminating Engineering Society, Nova Scotia Power, Nova Scotia Natural Resources
Prince Edward Island					
$mart Energy Management	This program assists manufacturers and processors in Prince Edward Island in reducing their energy costs through energy efficiency, mitigating GHG emissions in the process. The program includes energy efficiency workshops, development and distribution of an interactive CD-ROM on energy efficiency for the sector, and an energy auditing service.	CO_2	Voluntary Information	Implemented	PEI Department of Development and Technology
Quebec					
Promotion of Energy Efficiency	Any project or activity that may help to promote energy efficiency, stimulate the energy efficiency industry, or support the impact made by this industry abroad may be approved for a financial or professional contribution by the Energy Efficiency Agency. Public and para-public organizations in Quebec, non-profit companies, and non-profit organizations are all eligible.	CO_2	Economic	Implemented	Energy Efficiency Agency

Municipalities

Government of Canada

Community Energy Management	Includes two broad initiatives that have taken root in the Canadian planning profession. The first of these is a move to change the way in which neighbourhoods, towns, cities, and regions are designed. The overarching principle is to create more "livable" environments that improve accessibility to services and employment, preserve green space, reduce pollution and noise, and generally create a safer urban landscape with a greater sense of place and community. The second initiative is the focus on meeting society's energy service needs in ways that minimize energy consumption, with potential economic and environmental benefits. This initiative is directed at choices about energy delivery systems, district heating and cooling, combined heat and power, renewable energy, building energy and resource efficiency, passive solar design, reduced building heat loss, and reduced water consumption and wastewater production.	CO_2	Economic Regulatory Information	Implemented	National Climate Change Process
Community Energy Systems	Assists Canadian communities to meet their energy needs by identifying and developing opportunities for the use of district heating and cooling, combined heat and power, waste heat recovery, thermal storage, and local sources of renewable energy, particularly biomass.	CO_2	Information Economic	Implemented	Natural Resources Canada
Green Municipal Enabling Fund	The Green Municipal Enabling Fund will increase municipal access to innovative and cost-effective energy services, such as district energy systems, renewable energy, and energy efficiency. The fund pays for 50% of feasibility studies for innovative environmental projects within municipal operations. The Green Municipal Enabling Fund will also address the issue of climate change by supporting projects designed to improve energy efficiency and thus reduce GHG emissions.	CO_2, CH_4	Economic	Implemented	Government of Canada, Federation of Canadian Municipalities
Green Municipal Investment Fund	The Green Municipal Investment Fund will increase municipal access to innovative and cost-effective energy services, such as district energy systems, renewable energy, and energy efficiency. The fund provides loans for up to 25% of capital projects that will allow eligible recipients to carry out environmental projects within municipal operations. The Green Municipal Investment Fund will also address the issue	CO_2, CH_4	Economic	Implemented	Government of Canada, Federation of Canadian Municipalities

Government of Canada (continued)					
	of climate change by supporting projects designed to improve energy efficiency and thus reduce GHG emissions. The Green Municipal Investment Fund will provide grants, loans, and loan guarantees for projects that increase the environmental efficiency and cost-effectiveness of existing municipal water, wastewater, waste, energy, and public transportation facilities.				
Landfill Gas Capture	An increasing number of Canadian municipalities are implementing landfill gas recovery. In addition to eliminating the risks related to landfill gas emissions, the gas can often be used or sold for its energy content. The 1.2 million tonnes of CH_4 currently generated at Canadian landfills has the equivalent energy of 9 million barrels of oil or enough energy to heat more than 600 000 homes annually. About 25% of the landfill gas being emitted by Canadian landfills is being captured; of that, about 70% of the gas is utilized and the remaining 30% is flared. The majority of the gas is used for electricity generation. Other applications range from simply heating buildings to providing fuel for a gypsum manufacturing plant, a cement plant, and a recycling plant.	CO_2, CH_4	Economic Regulatory	Implemented	National Climate Change Process
Municipal Building Retrofit Program	The program encourages the adoption of energy efficiency in the municipal sector by offering municipalities all of the elements necessary to identify, develop, finance, and implement comprehensive building energy retrofits.	CO_2	Information	Implemented	Natural Resources Canada, Federation of Canadian Municipalities
Partners for Climate Protection	This program is a partnership between the Federation of Canadian Municipalities and the International Council of Local Environmental Initiatives that helps municipal governments reduce GHG emissions.	CO_2	Information	Implemented	Federation of Canadian Municipalities, International Council of Local Environmental Initiatives
Alberta					
Eco-Efficient Communities Initiative	Provides municipalities with the practical information and tools to reduce GHG emissions. The program is designed for small and mid-sized communities in Alberta, which often do not have the in-house staff and resources for independent energy efficiency exploration. The program, delivered by the Pembina Institute, offers a range of project materials, workshops, and conferences that are available to any local government.	CO_2	Information	Implemented	Pembina Institute

Alberta (continued)					
Greenhouse Gas Emissions Reduction Plan – Edmonton	This plan provides a strategy for reducing GHG emissions from the city's buildings, facilities, operations and transit fleet, wastewater treatment plant, and street lighting.	CO_2	Policy Information	Implemented	Government of Alberta,
Kikino Metis Settlement Pilot Initiative	A pilot project to identify GHG reduction opportunities and encourage action. The Alberta government and partners, including the Kikino Metis Settlement, TransCanada, Alberta-Pacific Forest Industries Inc., and the federal government, are working together to help shape future community engagement initiatives in other Alberta communities.	CO_2	Information	Implemented	Kikino Metis Settlement, TransCanada, Alberta-Pacific Forest Industries Inc., Government of Canada
Natural Gas Service Extended to Three Metis Settlements	Under the Rural Gas Grant Program, natural gas service was extended to three Metis settlements in Northern Alberta.	CO_2	Fiscal	Implemented	Government of Alberta
Okotoks Sustainable Development Plan	In September 1998, the Town of Okotoks, Alberta, became one of the first communities in Canada to recognize its environmental limits to growth. The community chose to see the town function within the limits of the local environmental capacity.	n.a.	Information Policy	Implemented	The Town of Okotoks
Sustainable Communities Initiative	Supports local community efforts to achieve sustainability. Initiative has helped communities develop and implement action plans on waste, green spaces, transportation, sustainable housing, and other grassroots projects. The program has been implemented in eight communities across Alberta.	CO_2	Information	Implemented	Alberta Environment, FEESA
British Columbia					
Energy Aware Committee	Works with interested local British Columbia governments to promote and support Community Energy Planning (CEP). Over the last two years, the committee has conducted workshops for local governments in the Greater Vancouver Regional District, the Central Okanagan, the Capital Regional District, and the City of Abbotsford. These workshops help communities examine the energy efficiency opportunities presented through CEP and identify opportunities to implement energy efficiency initiatives.	CO_2	Information	Implemented	British Columbia

British Columbia (continued)					
Greening Communities Initiative	The main activity of this program is to provide matched funds to a local government and community partnership for the development and implementation of projects that link strategies for GHG emissions reductions and improvement in social and economic conditions.	CO_2	Economic	Implemented	Government of Canada, Federation of Canadian Municipalities, Union of British Columbia Municipalities
Partners for Climate Protection	Several British Columbia municipalities are involved in the Partners for Climate Protection program, led by the Federation of Canadian Municipalities. The Greater Vancouver Regional District, its member municipalities, and neighbouring regional and local governments are actively involved in the Regional and Local Government Working Group on Climate Change to share information and expertise on implementation of GHG emissions reduction initiatives. The district is also actively involved in several GHG initiatives through its Air 2000 program, including high-volume flash concrete, solar thermal pool retrofits, better building partnerships, and GHG action guide.	CO_2	Information	Implemented	Federation of Canadian Municipalities, The Greater Vancouver Regional District, Government of British Columbia
TravelSmart Program, Kamloops	The city of Kamloops launched this program in 1997, which, instead of building new roads to accommodate land use plans, integrated land use and transportation planning and focused on alternative neighbourhood designs and travel modes, including transit system options and promoting changes in travel behaviour.	CO_2, N_2O	Policy	Implemented	The City of Kamloops
New Brunswick					
Partnership Initiatives	The objective is to encourage voluntary action by actively supporting the delivery of energy efficiency programs through partnership arrangements. Examples include in-kind support to the NB Lung Association in the delivery of the Wood Stove Campaign and Healthy Schools Program and the R-2000 program, which is delivered by the NB Home Builders Association.	CO_2	Voluntary Information	Implemented	Government of New Brunswick
Northwest Territories					
Establishment of the Arctic Energy Alliance	A non-profit society established through a partnership of several organizations. The mandate of the Alliance is to help communities, consumers, producers, regulators, and policy makers to work together to reduce the cost and environmental impacts of energy in the Northwest Territories.	CO_2	Information	Implemented	Government of the Northwest Territories, The NWT Power Corporation, The NWT Housing Corporation, The NWT Association of Municipalities, The NWT Public Utilities Board

Nunavut					
Energy Management	The energy management program in Nunavut promotes energy management and community energy planning with local government, Nunavut regional staff, and other decision makers; raises awareness of the Arctic Energy Alliance and its program; performs energy assessments of major buildings and facilities; and determines the potential for energy management projects that would ensure benefits to the community. The initiative is currently active in nine communities.	CO_2	Information	Implemented	Government of Nunavut
Residual/ Waste Heat Systems	Organizations responsible for community planning, transportation, and building services need to work together to develop and implement community energy plans.	CO_2	Economic	Implemented	Government of Nunavut
Ontario					
Building Retrofit Program – Ottawa	Introduction of a comprehensive retrofit program, including street light conversions.	CO_2	Other	Implemented	City of Ottawa
Community Climate Change Action Plan – Ottawa	This plan establishes strategies that will help the city move toward long-term sustainability. This plan is updated regularly, and implementation is ongoing.	CO_2, CH_4	Policy	Implemented	The City of Ottawa
Continuous Improvement System for Waste Management – London	The City of London has a package of measures contained within the Continuous Improvement System for Waste Management. The system reexamines current efforts and pursues practical innovations to improve waste management measures. The computer model used measures GHG emissions, emissions of acid rain and smog precursors, and air emissions of heavy metals and dioxins.	CO_2, N_2O	Policy Information	Implemented	The City of London
Cornwall Electric Co-generation	Municipal power system built with a capacity to produce heat as a by-product of electrical generation.	CO_2	Policy	Implemented	Cornwall Electric
ecoPerth – Perth	The Town of Perth has become a model community in its response to the issue of climate change. The Town's ecoPerth program has the objectives of bringing climate change issues to the forefront of the community's consciousness, as well as to reduce the total GHG	CO_2, CH_4	Policy Information Education	Implemented	The Town of Perth

Ontario (continued)					
	emissions by more than 20% by the year 2010 and to integrate sustainability into the social and fiscal fabric of the community.				
Energy Management Services – London	The City of London has recently completed a comprehensive energy management project in facilities the town owns and operates. The primary goal in this review was to reduce energy consumption through implementation of new technology in buildings, retrofits, building automation systems, and conversion to natural gas as a primary fuel source.	CO_2	Policy	Implemented	The City of London
Green-Up – Peterborough	Offers household evaluations of energy, waste, and water use and recommends lifestyle changes to use resources more efficiently.	CO_2	Information Education	Implemented	City of Peterborough
Residential Energy Efficiency Program	Energy appraisal system and a community-based social marketing strategy in the Waterloo Region will be completed over two years. The project seeks to build public awareness and understanding of the climate change issue and the link to personal energy consumption.	CO_2	Education Information	Implemented	University of Waterloo
Prince Edward Island					
Diversion from Landfill and Composting of Organics	The Island Waste Management Corporation (IWMC) is responsible for the management of all solid waste on Prince Edward Island, including the implementation of the Waste Watch Program. Waste Watch, which is currently running in selected areas of the province, is a three-stream source separation system that includes recycling, compost, and waste. Currently, 10 000 t of organic matter are diverted from landfill annually. The IWMC anticipates that by 2002, the Waste Watch program will be operational Island-wide and that 30 000 t of organic material will be diverted from landfill per year and composted. The quantities of CH_4 and CO_2 produced in composting are far less than those produced by the same quantity of organics in a landfill situation.	CO_2, CH_4	Policy	Implemented	Province of Prince Edward Island, The Island Waste Management Corporation

Quebec					
Commission scolaire de la Rivière-du-Nord Budget Decentralization	Revised energy budget as a means to realize a 10% reduction of GHGs emitted by each of the Commission's 47 schools or buildings. Each building will engage in technical reviews, create an energy budget, implement energy programs, and conduct follow-up.	CO_2	Policy	Implemented	Commission scolaire de la Rivière-du-Nord
Energy Efficiency Committee – Lachine	The committee's mandate is to reduce annual energy consumption by 10%, lower GHG emissions, and provide awareness and training to employees. Improved energy efficiency and the use of alternative fuels in a number of projects have led to reductions in energy use and GHG emissions.	CO_2	Policy Information Education	Implemented	The City of Lachine
Saskatchewan					
Big Five Performance Contract – Saskatoon	The Big Five Performance Contract covers five leisure complexes within Saskatoon and provides capital funding and expertise to evaluate and implement energy-saving measures. Implementation of these measures in several municipal buildings and facilities has resulted in reduced energy use and GHG emissions.	CO_2	Policy	Implemented	The City of Saskatoon
Yukon					
Commercial Energy Auditor Service	This service trains and certifies commercial energy auditors based on the Canadian Institute for Energy Training.	CO_2, SO_2	Information	Implemented	Yukon Development Corporation
Greenhouse Gas Inventory for Whitehorse	The City of Whitehorse is planning to conduct an inventory of GHG emissions using the Federation of Canadian Municipalities database software. This will produce baseline data for sources of emissions within both the community and the City operations. This is seen as the first step toward developing programs to reduce GHG emissions.	n.a.	Research Information	Implemented	The City of Whitehorse
Project Yukon Community Development Fund	This program assists municipal and First Nations governments and community non-profit organizations to implement projects to improve the quality of community life. Energy-related projects include wind energy monitoring, solar power, an educational wind turbine, a wood-fired district energy system, and a series of workshops to increase energy efficiency in recreation facilities.	CO_2	Information Technology Transfer	Implemented	Yukon Economic Development

Yukon (continued)					
Project Yukon Community Development Fund	This program assists municipal and First Nations governments and community non-profit organizations to implement projects to improve the quality of community life. Energy-related projects include wind energy monitoring, solar power, an educational wind turbine, a wood-fired district energy system, and a series of workshops to increase energy efficiency in recreation facilities.	CO_2	Information Technology Transfer	Implemented	Yukon Economic Development
Watson Lake District Heat	This project involved the installation of a heat exchanger on the exhaust of the most frequently used generators to supply heat to town facilities. Recovered waste heat is used to heat several large buildings and the town's swimming pool.	CO_2, SO_2	Policy	Implemented	The Watson Lake Council, Yukon Electrical Company
Transport					
Government of Canada					
Alternative and Future Transportation Fuels	Encourages the development, production, and use of alternative and future vehicle and fuel technologies. The focus is on a number of fuels, including propane, natural gas, and alcohols, as well as on electricity and hydrogen. The program provides support to fleet operators in the public and private sectors through economic and market studies, emissions, and safety assessments; market demonstration, communications, and awareness activities; and general and technical information about fuel options.	CO_2, N_2O	Information Education	Implemented	Natural Resources Canada
Auto $mart Program	Promotes energy-efficient practices among Canadian motorists through publications, events, joint projects, and a Student Driver Kit available to driver trainers across Canada. Motorists also receive helpful tips on buying, driving, and maintaining their vehicles to reduce fuel consumption and GHG emissions.	CO_2, N_2O	Information Education	Implemented	Natural Resources Canada
Comprehensive Transport Management Training – China	This project is designed to strengthen China's managerial, planning, and operational practices in the transportation sector, resulting in decreased GHG emissions from this sector.	CO_2, N_2O	Policy Information	Implemented	Canadian International Development Agency

Government of Canada (continued)					
Development and Demonstration of Hydrogen Fleet Fuel Appliance	The project consists of the development of a system for improving the refuelling of hydrogen fuel cell-powered buses and other vehicles at a reduced cost. With the new high-volume refuelling system, bus companies running fuel cell vehicles will be able to refuel more vehicles overnight and thus reduce their costs by taking advantage of off-peak electricity rates.	CO_2, N_2O	Research	Planned	Industry Canada
Emissions Research and Measurement Division	Provides support to a number of industry and government programs directed at developing new technologies for reducing GHG emissions from the transportation sector. Activities include characterization of emissions for gasoline and diesel engines, hybrid vehicles, fuel conservation systems, fuel cells, and related equipment.	CO_2	Research	Implemented	Environment Canada
EnerGuide for Vehicles	The program provides prospective new-vehicle buyers with information on energy consumption and costs to enable them to compare and purchase the most fuel-efficient vehicle that meets their needs. Includes information on all new vehicles sold and a complete listing of fuel consumption information for all new vehicles, and identifies the most fuel-efficient vehicles in different categories.	CO_2, N_2O	Information Education	Implemented	Natural Resources Canada
Environmental Management Program – Bangladesh	This project aims to strengthen the institutional capacity of Bangladesh's Department of Environment. Activities include establishing environmental management demonstration areas and implementing environmental initiatives, which can help reduce GHG emissions, including a demonstration project targeting the conversion of rickshaws to natural gas.	CO_2, N_2O	Policy Information	Implemented	Canadian International Development Agency, KPMG-Halifax, Resources Futures International, University of Ottawa, Dalhousie University, Bangladesh Department of Environment
Excise Tax Exemption for Ethanol and Methanol	The federal government's Excise Tax Exemption for Ethanol and Methanol Program provides a 100% exemption from the $0.10 per litre excise tax on gasoline for ethanol and methanol made from biomass that is blended with gasoline.	CO_2, N_2O	Economic	Implemented	Natural Resources Canada, Finance Canada

Government of Canada (continued)					
FleetSmart	Helps fleet managers reduce fuel costs and vehicle emissions through energy-efficient practices. The program develops energy use data and profiles for fleet segments and provides a range of products, such as an energy management tool kit, success stories and case studies that identify best practices, and training initiatives.	CO_2, N_2O	Information Education	Implemented	Natural Resources Canada
FleetWise	FleetWise aims to help federal government departments increase the efficiency of their fleets in order to cut costs and minimize the negative environmental impacts from the operation of fleet vehicles. The program builds on sound management practices by improving vehicle utilization, reducing fuel consumption, increasing the efficiency and environmental performance of vehicle operations, and encouraging greater use of alternative fuels.	CO_2, N_2O	Policy	Implemented	Natural Resources Canada
Intelligent Transportation System (ITS)	This plan sets out the federal government's strategy for stimulating the development and deployment of these systems across urban and rural Canada. The goals are to maximize the use and efficiency of existing infrastructure and meet future mobility needs more responsibly. The ITS Plan provides leadership and support to advance the application and compatibility of ITS technologies to make Canada's multimodal ground transportation system safe, integrated, efficient, and sustainable.	CO_2, N_2O	Information	Implemented	Transport Canada
MOEF Institutional Strengthening – India	This project will strengthen the capacity of the Indian Ministry of Environment and Forests (MOEF) to address a broad range of environmental issues, one of which is converting three-wheel vehicles to natural gas, thereby reducing GHG emissions.	CO_2	Policy Information	Implemented	Environment Canada, Canadian International Development Agency
Moving On Sustainable Transportation	Supports projects that produce the kinds of education, awareness, and analytical tools Canada needs if we are to make sustainable transportation a reality. Program provides funding to help support projects that will provide practical information and tools to better understand sustainable transportation needs; encourage the creation of innovative ways to promote sustainable transportation; and achieve quantifiable environmental and sustainable development benefits.	CO_2	Information Education	Implemented	Transport Canada

Government of Canada (continued)					
National Biomass Ethanol Program	In December 1994, the federal government reiterated its support for the production and use of fuel ethanol by announcing the National Biomass Ethanol Program. This program introduced a $70-million, government-guaranteed line of credit that will make it easier for manufacturers to obtain private sector financing for ethanol plants, and will also provide a means of rescheduling their long-term debt in the event of financial difficulties. The line of credit is intended to assist ethanol manufacturers should a future government change the excise tax on fuel ethanol.	CO_2, N_2O	Economic	Implemented	Natural Resources Canada, Finance Canada
Natural Gas for Vehicles	An incentive program designed to encourage the production and use of natural gas vehicles. The program contributes funds for road vehicles converted to natural gas. The program also encourages the development of new refuelling outlets, cost-shared marketing and awareness activities, and co-funded research and development.	CO_2, N_2O	Economic	Implemented	Natural Resources Canada
Transportation Energy Technologies Program	Transportation Energy Technologies Program (TETP) supports efforts by Canadian industry to develop and deploy technologies and fuels that provide a cleaner, more sustainable energy mix for our roadways. TETP assists industry in responding to a growing worldwide demand for more environmentally responsible transportation alternatives, while enhancing Canada's competitive edge in the changing transportation marketplace. Key activities include the development of electric vehicles and hybrids, fuel cells, and alternative transportation fuels, including natural gas, propane, ethanol, methanol, and hydrogen.	CO_2, N_2O	Research	Implemented	Natural Resources Canada
Vehicle Fuel Efficiency Program	Program promotes improvements in vehicle fuel efficiency by encouraging motor vehicle manufacturers to meet voluntary annual company average fuel consumption targets for new automobiles. Working with vehicles, this initiative focuses on opportunities to improve vehicle fuel technology and provide information to consumers on the fuel efficiency of vehicles.	CO_2, N_2O	Voluntary	Implemented	Natural Resources Canada

Alberta					
Green Corridors	This program seeks to mitigate GHG emissions by establishing green corridors, or alternative refuelling infrastructure, along major transportation routes in Alberta.	CO_2, N_2O	Policy Fiscal	Implemented	Government of Alberta
Intelligent Transportation System	This measure includes such actions as adaptive signal control systems and traveller information systems.	CO_2, N_2O	Policy Fiscal	Implemented	Government of Alberta
Low Emissions Transit Bus Pilot Project	Under this program, Alberta urban municipalities would have the opportunity to test-market innovative fuel-efficient bus technology.	CO_2, N_2O	Policy Fiscal	Implemented	Government of Alberta
Transit Enhancement	Measures aimed at increasing transit use in urban centres through provincial and federal funding to improve transit service and expand infrastructure.	CO_2, N_2O	Policy Fiscal	Implemented	Government of Alberta
British Columbia					
Alternative Fuel Vehicles	A purchase of 150 natural gas or propane vehicles to replace aging fleet vehicles. Fifty natural gas buses have been purchased in recent years.	CO_2, N_2O	Policy	Implemented	Ministry of Transportation and Highways
Ballard Hydrogen Fuel Cell Technology	Since 1991, Natural Resources Canada has provided technical and financial assistance to Ballard Power Systems of Vancouver to develop fuel cell technology for transportation. This involved field trials in the early 1990s, followed by field trials on a full-sized bus. The first fuel-cell-powered bus was launched in 1994. The 40-foot fuel cell bus is now operational. The current phase of the program involves testing three bus fleets of three buses each.	CO_2, N_2O	Economic	Implemented	Natural Resources Canada, Ballard Power Systems
Clean Vehicles and Fuels Program	The Clean Vehicles and Fuels Program is the strongest and most thorough program of its kind in Canada. It includes tough regulations and programs to mandate and promote cleaner fuels and vehicles, and thereby emissions.	CO_2, N_2O	Regulatory	Implemented	Ministry of Transportation and Highways
Consultation on Options to Reduce GHGs from Light Trucks and Passenger Vehicles	Consultation with stakeholders to identify and evaluate options to reduce GHG emissions from passenger vehicles and light trucks, including the option of a "feebate" system based on vehicle fuel efficiency.	CO_2, N_2O	Policy	Implemented	Ministry of Finance and Corporate Relations

British Columbia (continued)					
Cycling Network Program	Invests annually to aid the development of cycling infrastructure in various communities.	CO_2, N_2O	Economic	Implemented	Ministry of Transportation and Highways
Ethanol Development Program	Production of fuel ethanol from wood residue has major potential to reduce GHG emissions from the transportation sector, reduce wood smoke, and provide added value to the forest sector. Released a study on the feasibility of making ethanol from B.C. wood residue and the available wood-to-ethanol technologies.	CO_2, N_2O	Economic	Planned	Ministry of Environment, Lands and Parks
Fuel Cell Technology Development	Through industry, institutional and government alliances and access to a hydrogen-ready laboratory infrastructure. Facilitate technology development and demonstration projects that allow fuel cell companies to test and perfect their new, pre-commercial fuel cell technologies.	n.a.	Research	Implemented	Government of British Columbia, Government of Canada
Gasoline and Diesel Tax for Public Transit	A gasoline and diesel tax is collected on behalf of certain public transit authorities for transit, in addition to the general fuel tax on gasoline and diesel.	CO_2, N_2O	Economic	Implemented	Ministry of Finance and Corporate Relations
High-Occupancy Vehicle (HOV) and "Bus Only" Lanes	Project to encourage the use of buses, van/carpools, and other high-occupancy vehicles.	CO_2, N_2O	Policy	Implemented	Ministry of Transportation and Highways
Intelligent Transportation Systems	Involves incident management and traveller information systems on the Trans-Canada Highway.	CO_2, N_2O	Information	Implemented	Ministry of Transportation and Highways
Long-term Tax Policy for Alternative Fuels	Implementation of a long-term general tax policy for all alternative motor fuels. Under the policy, tax rates on alternative motor fuels will be phased in, based on market share and environmental benefits, with the maximum tax rate below the gasoline tax rate. This will provide suppliers and consumers of alternative fuels with certainty that alternative fuels will receive preferential tax treatment over the long term, to encourage the development and distribution of these fuels and the purchase of alternative-fuel vehicles.	CO_2, N_2O	Economic Policy	Adopted	Ministry of Finance and Corporate Relations

British Columbia (continued)

Motor Assisted Bicycles	Legislation passed this year in British Columbia encourages people to use motor-assisted bicycles as an alternative mode of transportation. Such bicycles are fitted with an accessory motor kit for use up hills or when needed. Under the amendment to the *Motor Vehicle Act*, people riding motor-assisted cycles will not need vehicle registration, licences, or insurance.	CO_2, N_2O	Legislative	Implemented	Ministry of Transportation and Highways
Motor Fuel Tax Exemptions for Alternative Fuels	British Columbia provides a motor fuel tax exemption for natural gas and 85% ethanol and methanol blends of fuel used in motor vehicles. There is also a preferential tax rate for auto-propane of 7% of the price, significantly lower than the gasoline tax rate on an energy equivalent basis. A tax exemption will be provided for the ethanol used in lower-level gasoline–ethanol blends once a commercial-scale ethanol plant is in operation in the province.	CO_2	Economic	Implemented	Ministry of Finance and Corporate Relations
National Fuel Cell Research and Innovation Initiative	A National Fuel Cell Research Facility has been established at the National Research Council of Canada's Innovation Centre in Vancouver. The National Research Council, Natural Resources Canada, and the Climate Change Action Fund supports a research and technology demonstration and deployment program. As well, a university research fund has been established to build on work being done by the National Research Council and the Natural Sciences and Engineering Research Council.	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Research	Implemented	National Research Council of Canada, Natural Resources Canada, Natural Sciences and Engineering Research Council
Partial Sales Tax Rebate for Factory-Produced Alternative-Fuel Vehicles and Vehicle Conversions	British Columbia provides a provincial sales tax refund of up to $500 for purchases of eligible new factory-manufactured alternative-fuel vehicles and up to $5 000 for eligible alternative-fuel passenger buses. Kits and installation labour to convert existing motor vehicles to operate on alternative fuels such as propane, natural gas, and electricity are also exempted from provincial sales tax.	CO_2	Economic	Implemented	Ministry of Finance and Corporate Relations
Regional Growth and Transportation Demand Management	The provincial government is providing technical support to local and regional governments in the main urban growth areas (Lower Mainland, Okanagan Valley, and Greater Victoria) to help them develop regional growth and transportation demand management strategies.	CO_2, N_2O	Policy	Implemented	Ministry of Transportation and Highways

British Columbia (continued)					
(TDM) Strategies	These strategies are aimed at reducing vehicle emissions by designing settlement patterns and transportation modes that decrease vehicle use and shorten travel distances. The Greater Vancouver Regional District, for example, is taking action to control vehicle-related emissions under its Air Quality Management Plan. The main initiatives involve shaping future growth in compact metropolitan communities, with improved public transit and TDM measures (e.g., the awareness-raising "Go Green" program) to discourage the use of single-occupant vehicles.				
SkyTrain Expansion	The provincial government has committed $1.167 billion to extend Greater Vancouver's rapid transit SkyTrain line and purchase 60 new SkyTrain vehicles, as the result of a June 1998 agreement with Bombardier Inc. The line, linking Vancouver to Coquitlam and New Westminster, will help control vehicle emissions (including GHG emissions) by providing a low-emission alternative to the motor vehicle. Completion is expected in 2001.	CO_2, N_2O	Economic	Implemented	Ministry of Transportation and Highways
TransLink	The B.C. legislature created the Greater Vancouver Transportation Authority, which became responsible for all transit and regional transportation functions in the Lower Mainland. Renamed "TransLink" in April 1999, this new regional transportation network is intended to improve transportation management in the region, reducing energy consumption and related GHG emissions.	CO_2, N_2O	Policy	Implemented	Ministry of Transportation and Highways
Manitoba					
Ethanol Blend Tax Relief	A tax forgiveness of 2.5 cents per litre is allowed for blends of 10% alcohol in gasoline sold in the province of Manitoba. The alcohol must be derived from biomass materials, be denatured, and not contain more than 1% water. The tax relief applies only to the gasoline containing alcohol that is produced and consumed in Manitoba.	CO_2, N_2O	Economic	Implemented	Government of Manitoba
Manitoba Conservation Vehicle Replacement Program	The Manitoba Department of Conservation has committed to replacing all vehicles due for replacement with the most fuel-efficient vehicles available for the duties required. Eighty vehicles have been replaced, and fleet sizes have been downsized where appropriate.	CO_2, N_2O	Policy	Implemented	Government of Manitoba

New Brunswick					
TRAX	A public education program to reduce the use of private vehicles and encourage mass transportation/car pooling/ walking/bicycling as viable healthy alternatives. Several major employers in the core of Halifax will be assisted in setting up in-house programs. Existing efficient public transportation initiatives will be supported and efforts undertaken to change/introduce legislation that will encourage more efficient public transportation. Partnership with the health field will emphasize the negative aspects of personal vehicles and the positive aspects of alternatives.	CO_2, N_2O	Information	Implemented	Ecology Action Centre, Nova Scotia Department of Natural Resources, Department of Transportation, City of Halifax, Metro Transit, Environment Canada
Nova Scotia					
Driver Education	The objective of the Driver Education Program is to encourage the adoption of energy efficiency into driver-training curriculum. The activity involves marketing of curriculum material developed by Natural Resources Canada to driving schools in the province.	CO_2, N_2O	Information Education	Implemented	Department of Natural Resources and Energy, Natural Resources Canada
Ontario					
Anti-Smog Action Plan	Plan includes current initiatives and future actions to reduce smog-causing pollutants.	CO_2	Policy	Implemented	Ministry of the Environment
Carpool Lots	A program of continued construction at selected highway interchanges of lots adjacent to the highways, to increase carpooling.	CO_2, N_2O	Policy	Implemented	Ministry of Transportation
Drive Clean and Smog Patrol	One of the most comprehensive emission-testing programs in North America. In April 1999, the Drive Clean program began mandatory vehicle testing. The truck and bus component of the program began in September 1999. Ontario will be one of only three jurisdictions in North America testing trucks and buses, as well as cars. The program is projected to reduce emissions of smog-causing pollutants from vehicles in the program area over the course of the program. GHG emissions are also projected to decline.	CO_2, N_2O	Regulatory	Implemented	Ministry of the Environment
Intelligent Transportation Systems	Integrated freeway management program to eliminate vehicle idling and traffic congestion, thereby decreasing emissions.	CO_2, N_2O	Information	Implemented	Ministry of Transportation

Ontario (continued)					
Shortline Railways Act	Legislation created to facilitate the establishment of shortline rail operations. This legislation will promote shifting freight loads from road to rail and reduce truck traffic.	CO_2, N_2O	Legislation	Implemented	Ministry of Transportation
Statement of Environmental Values	Ensures that all new significant policies and programs must be screened for environmental implications and create opportunities to identify potential GHG emissions before they occur.	CO_2, N_2O	Policy Legislation	Implemented	Ministry of Transportation
Transit-Supportive Land Use Planning Guidelines	Providing guidelines for city planners and designers to promote compact urban forms, transit-supportive development densities, and mixed-use practices to reduce vehicle emissions.	CO_2, N_2O	Policy	Implemented	Ministry of Municipal Affairs and Housing
Prince Edward Island					
Advanced Fleet Management System for the Provincial Highway Maintenance Fleet	This program will utilize Intelligent Transportation Systems in planning, implementing, and deploying a fleet management system that will facilitate and foster improved route planning and scheduling of maintenance fleet; improved management of inventory control for materials; improved safety and efficiency of the maintenance fleet; real-time fleet location and status monitoring; improved response time for road salt/sand application; and reduced operating costs.	CO_2, N_2O	Policy Information	Implemented	PEI Department of Transportation and Public Works
Advanced Traveller Information System	A traveller information system that distributes information on weather, road conditions, construction zones, detours, and congestion by means of radio broadcasts, variable message signs, web pages, and/or other media. The Department is testing an Advanced Traveller Information System and is seeking ways to distribute existing information easily.	CO_2, N_2O	Information Voluntary Economic	Adopted	PEI Department of Transportation and Public Works
Greater Charlottetown Synchronized Traffic Signal System	Improving traffic flow through intersections through the application of Intelligent Transportation Systems (ITS) reduces vehicle emissions by minimizing idling times at red lights. Phase I, the widening of the intersection on the Charlottetown Perimeter Highway to allow for two through-lanes in each direction, has been completed, implementing time-based signal coordination along the	CO_2, N_2O	Regulatory Policy	Implemented	PEI Department of Transportation and Public Works

Prince Edward Island (continued)					
	entire section of highway. Phase II will expand the system to include University Avenue. If funding becomes available in the City of Charlottetown, implementation of Phase III will include the upgrading of the entire signalized network system (approximately 40 signalized intersections) to be fully adaptive for all signalized intersections in the Greater Charlottetown Area.				
PEI Enerpool	The program objective is to demonstrate the energy conservation potential through ride sharing The program sponsors two vans that provide weekday transportation to and from Charlottetown, Prince Edward Island.	CO_2, N_2O	Information Voluntary	Implemented	PEI Department of Development and Technology
Road Weather Information System (RWIS)	Improved knowledge of specific road conditions (temperature, moisture, wind speed, salt concentration) greatly improves road condition forecasting ability. RWIS enhances highway maintenance decision-making ability, leading to more efficient use of the highway maintenance fleet. Accurate, timely, and specific road condition information can help pinpoint problem areas and dispatch equipment accordingly.	CO_2, N_2O	Information	Implemented	PEI Department of Transportation and Public Works
Quebec					
Employer Program	A program developed a transport plan for businesses that includes a wide range of measures to facilitate travel by employees between home and workplace. It is designed to bring about change in travel habits by promoting public transport and ride sharing and rethinking the management of parking lots.	CO_2, N_2O	Voluntary Information	Implemented	Department of Transport
Public Transit Program	The program is designed to create conditions in the cores of major urban areas to encourage use of public transit as the main mode of travel, as well as encouraging the maintenance and development of efficient networks and services. The capital investment aspect of the program is designed to encourage maintenance of assets, improve infrastructures, and expand networks.	CO_2, N_2O	Economic Information	Implemented	Department of Transport

Saskatchewan					
Alternative Fuels Initiative	Demonstration of cost-effective and efficient alternative fuels such as natural gas. To date, approximately 130 SaskEnergy vehicles operate on natural gas; 125 of those are bio-fuel vehicles.	CO_2, N_2O	Policy Technology Demonstration	Implemented	SaskEnergy
Ethanol Incentive	The Government of Saskatchewan introduced a five-year ethanol incentive program that began in 2000. It is a rebated portion of the Fuel Tax to the fuel wholesaler on eligible ethanol-blended fuel produced and consumed in Saskatchewan.	CO_2, N_2O	Economic	Implemented	Government of Saskatchewan
Short-line Railway Advisory Program	This program provides technical, marketing, and legal advice to groups interested in setting up short line railways. Its objectives include reducing grain producers' transportation costs relative to truck transportation; minimizing damage to thin pavements due to heavy grain truck traffic; and reducing the taxation burden on rural residents associated with the elimination of railways and elevators. Six short-line railways are currently in operation, with a seventh in the process of being established. Total short-line trackage is expected to reach 1 200 km.	CO_2	Policy Economic	Implemented	Saskatchewan Department of Highways and Transportation
Trucking Partnership Program	The program provides an opportunity for companies to improve the efficiency of their hauling operation by allowing loads in excess of weights and/or lengths that can be legally hauled on the provincial highway system. The companies must meet specific operational requirements, including the sharing of haul savings with the Department. The objectives of the program are to support economic development in Saskatchewan; provide additional revenues for road improvement; promote the use of more efficient, road-friendly vehicle technology; and ensure that the taxpayers and motoring public are not adversely affected by industrial traffic.	CO_2, N_2O	Regulatory Economic	Implemented	Saskatchewan Department of Highways and Transportation
Volatile Organic Compounds Reduction	The program is reducing emissions of volatile organic compounds by cutting down the use of trichloroethylene in asphalt testing; promoting the use of emulsified asphalt instead of cutting back asphalt where possible; and increasing the use of water-based paint on road stripping.	VOCs	Voluntary	Implemented	Saskatchewan Department of Highways and Transportation

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
Saskatchewan (continued)					
5 Axle Sanding/Snow Plow Trucks	Through the use of new technology, reduce the number of snow plow/sanding trucks while maintaining the same level of service. Reduce the overall fuel consumption per unit of work.	CO_2	Policy	Implemented	Saskatchewan Department of Highways and Transportation
Yukon					
Alternative Fuel Vehicles	Government Services has been investigating the feasibility of using alternative fuel vehicles in the fleet. Their efforts to reduce the use of fossil fuels began with downsizing vehicle engines in 1993. They have purchased and tested propane vehicles and an electric car. The next step is to purchase a hybrid vehicle.	CO_2, CH_4	Research Information Education	Implemented	Government of Yukon
Anti-Idling Campaign	The Transportation Division of Community and Transportation Services is conducting a Vehicle Idling Reduction campaign for its employees during the winter of 2000–01. Through a series of fact sheets, the project aims to raise awareness about the environmental and financial costs of vehicle idling and discourage this practice. The effectiveness of the campaign will be assessed through a short questionnaire, as well as the calculation of maintenance vehicle fuel use. Based on these results, the program will be modified and possibly expanded to reach the entire department, Yukon government, and/or the general public.	CO_2, CH_4	Information Education	Implemented	Government of Yukon
Vehicle Emissions Testing	Yukon Renewable Resources, Environment Canada, and the City of Whitehorse collaborate on a vehicle emission-testing clinic held each June in Whitehorse. The public is invited to bring their vehicles to the clinic for a free check of air pollutants coming out of their tailpipes. Information is provided on climate change, the production of CO_2 (based on a correlation with gas consumption), vehicle maintenance, and driving tips to reduce emissions. Participants are advised how to correct problems if the vehicle does not pass the emissions test.	CO_2, N_2O	Policy Information	Implemented	Yukon Renewable Resources, Environment Canada, City of Whitehorse

Name of Policy Measure	Objective and/or Activity Affected	Gas(es) Affected	Type of Instrument	Status	Implementing Entity or Entities
Waste Management					
Government of Canada					
Demonstration of an Innovative Technology to Convert Landfill Gas to Liquified Natural Gas and CO_2	This project carried out by CFS Alternative Fuels Inc. is demonstrating the cost-effectiveness of turning landfill gas into liquified natural gas for vehicular fuel and pure CO_2 for industrial use. The demonstration is carried out at the Hartland Capital Regional District landfill.	CO_2, N_2O	Research	Implemented	Natural Resources Canada
Demonstration of Micro-turbine Technology Using Landfill Gas as a Fuel to Produce Electricity	This demonstration project at the Regional Municipality of Ottawa-Carleton Trail Road landfill is demonstrating the use of the Honeywell 75kW microturbine using landfill gas to generate electricity.	CO_2, CH_4	Research	Implemented	Natural Resources Canada, Environment Canada
Enhanced Anaerobic Digestion of Municipal Solid Waste with Energy Recovery	The project consists of the development and demonstration of SUBBOR, an innovative approach to the treatment of the non-recyclable biomass components of municipal solid waste. The project will involve modified anaerobic digestion (a two-step process), followed by power generation and stabilization of the solid residue for use.	CO_2, CH_4	Research	Implemented	Industry Canada
Alberta					
Calgary Landfill Design Project	A project to study landfill designs for the control of landfill gas emissions (including CH_4). The project involves the building of two experimental landfill cells for studying lining/capping materials for landfills.	CO_2, CH_4, N_2O	Research	Implemented	Alberta Environment, City of Calgary, University of Calgary

Ontario					
New Landfill Standards	Requires the collection of landfill gas from large new and expanding landfills with more than 2.5 million tonnes waste capacity.	CH_4	Policy	Adopted	Ontario Ministry of the Environment
Prince Edward Island					
Diversion from Landfill and Composting of Organics	The Island Waste Management Corporation (IWMC), a provincial Crown corporation, is responsible for the management of all solid waste on Prince Edward Island, including the implementation of the Waste Watch Program. Waste Watch, which is currently running in selected areas of the province, is a three-stream source separation system that includes recycling, compost, and waste. Currently, 10 000 t of organic matter are diverted from landfill annually. The IWMC anticipates that by 2002, the Waste Watch program will be operational Island-wide and that 30 000 t of organic material will be diverted from landfill per year and composted. The quantities of CH_4 and CO_2 produced in composting are far less than those produced by the same quantity of organics in a landfill situation.	CO_2, CH_4	Policy	Implemented	The Island Waste Management Corporation, PEI Department of Fisheries, Aquaculture and Environment
Yukon					
Waste Watch	This curbside compost collection pilot project was implemented by the City of Whitehorse in 1996. Approximately 230 participating households separate their waste into compostables, recyclables, hazards, and garbage. While residents take their recyclables and hazards to a recycling depot, the City collects compostables and garbage on alternate weeks. The objectives of this initiative are to reduce residential waste by 50%, turn waste into compost, and reduce CH_4 gas by diverting organics from the landfill.	CH_4	Economic	Implemented	City of Whitehorse

Cross-Sectoral Initiatives

Government of Canada

Action Plan 2000 on Climate Change	The Action Plan 2000 on Climate Change, the Government of Canada's contribution to the First National Business Plan, will achieve a significant reduction in CO_2 emissions. This $500 million undertaking will address CO_2 emissions in a wide array of sectors, including transportation, electricity, CO_2 capture and storage, buildings, agriculture, forestry, minerals and metals, and industry.	CO_2	Economic Research Information Education	Implemented	Government of Canada
Adaptation and Impacts Research Program	Program promotes and conducts research designed to increase understanding of atmospheric change impacts and the required adaptations. These research activities are designed to provide information on the environmental, social, and economic risks and impacts caused by vulnerabilities to atmospheric change, variability, and extremes, and on the viability of adaptive responses. The program focuses on a number of key research themes (e.g., integrated assessments, health and atmospheric change, human dimensions of weather and climate, water and climate variability and change, integrated air issues, adaptation and impacts science) and works in partnership with selected universities and international collaborators.	CO_2, CH_4	Research	Implemented	Environment Canada
Adapting to Climate Change Impacts on the Landscape	This program, a combined government, university, and industry effort, is assessing how climate change could affect selected aspects of the Canadian landscape in order to help decision makers determine their adaptation options. Current topics include sea level rise impacts on the coasts of the Western Arctic and Prince Edward Island, landslides in the Rocky Mountains, slope stability implications for pipelines across Canada, drought frequency on the Prairies, permafrost thaw and impacts on infrastructure in the Northwest Territories, and flooding in the Red River Basin.	CO_2, CH_4	Research Information	Implemented	Natural Resources Canada
Arctic Climate Science Research Cooperation with Japan	A bilateral partnership with Japan, which will feed into international programs. The science generated will fill knowledge gaps and form the basis for policy deliberations on climate change impacts on biodiversity, human conditions, marine habitat, carbon sequestration potential, and issues of pollutants in the Arctic Ocean.	CO_2, CH_4	Research	Adopted	Fisheries and Oceans Canada, Natural Resources Canada, Environment Canada

Government of Canada (continued)					
Baseline Protection Initiative	This initiative will offer corporations/governments the opportunity to track actions resulting in emissions reductions. The initiative has both a policy-making capacity and a registry with aims complementary to other government actions.	n.a.	Information	Implemented	Government of Canada
BIOCAP	BIOCAP is a non-profit foundation that supports scientific, technological and policy research on mitigating GHG emissions through bio-based carbon sinks, energy, chemical and material resources.	CO_2, CH_4, N_2O	Research	Implemented	Government of Canada, Queens University
Canadian Council of Ministers of the Environment Indicators Study of Climate Change	This project will develop preliminary indicators of climate change in Canada and publish them in a public-friendly document.	CO_2, CH_4, N_2O	Policy Information	Adopted	Environment Canada
Canadian Environmental Solutions	An interactive database of Canadian companies that provide technological assistance to a wide range of environmental problems and renewable energy requirements.	CO_2	Information	Implemented	Industry Canada
Canadian Foundation for Climate and Atmospheric Sciences	Operates as an independent body. This is the largest single investment in university research in these areas in Canadian history. The Canadian Foundation for Climate and Atmospheric Sciences will do science research in climate change, extreme weather, and air quality.	CO_2, CH_4, N_2O	Research Education Information	Planned	Government of Canada
Canadian Glaciology Program	This program collects and analyzes core samples from High Arctic and Cordilleran glaciers for past temperatures, snow accumulation, and atmospheric concentrations of GHGs, contributing to the international body of data that is needed to understand the long- and short-term effects of climate change.	CO_2	Research	Implemented	Natural Resources Canada
Canadian GHG Verification Centre	This centre serves as a central clearinghouse for collecting, maintaining, updating, and sharing the latest documentation and tools required for the measurement and verification of GHG emissions reduction projects and technologies. The centre will also assist in developing methodologies, provide technical services, and facilitate the establishment of trained and accredited verification entities that would perform measurement, monitoring, and verification.	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Information	Implemented	Environment Canada

Government of Canada (continued)					
China Council for International Cooperation on Environment and Development – China	The project assists China in developing integrated policies highlighting the critical linkages between environmental sustainability and economic and social development. It supports the China Council for International Cooperation on Environment and Development, a high-level non-governmental consultative organization that strengthens cooperation and exchange between China and the international community on environment and development.	CO_2, CH_4	Policy	Implemented	Canadian International Development Agency, Simon Fraser University, State Environment Protection Agency
Clean Development Mechanism (CDM)/Joint Implementation (JI) Office	Canada's CDM/JI Office was established in 1998 as the federal government focal point on the Clean Development Mechanism and Joint Implementation, two project-based mechanisms under the Kyoto Protocol. The Office facilitates Canadian participation in CDM/JI, evaluates and approves project proposals submitted by Canadian entities, and assists with host country approval processes, including strategic cooperation agreements with the host countries. It also provides technical guidance to companies participating in CDM/JI.	CO_2, CH_4, N_2O	Policy Economic	Implemented	Department of Foreign Affairs and International Trade
Climate Change Action Fund (CCAF) Extension	The Climate Change Action Fund Extension was announced as a $150 million, three-year initiative over the 1998/99–2000/01 period. It funds economic and policy analysis, as well as federal policy coordination and early action to reduce emissions. The primary objectives of the CCAF were to demonstrate the federal government's commitment to ensuring that Canada meets its climate change obligations and to help lay the groundwork for a National Implementation Strategy on Climate Change, developed in concert with the provinces and territories, industry, and other stakeholders.	CO_2, CH_4, N_2O	Economic Research Information Education	Implemented	Government of Canada
Climate Change Skills and Knowledge Transfer Program	The Soil Conservation Council of Canada delivers this initiative via its "Taking Charge" program, to assist farmers in identifying best management practices that can reduce GHG emissions. Activities supported by this program include the coordination and development of "grassroot" provincial teams to raise farmers' awareness of climate change issues; the development of information tools; the holding of provincial workshops on GHG-reducing activities; and a national conference to further their understanding of climate change issues.	CO_2, CH_4, N_2O	Information Education	Implemented	Agriculture and Agri-Food Canada, Soil Conservation Council of Canada

Government of Canada (continued)					
Climate Modelling and Analysis Program	Program develops and uses sophisticated atmospheric and coupled climate models and advanced analysis of observed data and model output to improve understanding of present, past, and future climates. The models and analysis tools are used in short-term climate forecasting, for studies of climate predictability and variability, and to project and analyze the future climate change that will result from the anthropogenic changes in the composition of the atmosphere.	CO_2	Research Information	Implemented	Environment Canada
Climate Monitoring and Data Interpretation Program	Monitors and analyzes the Canadian and global climate to document and understand climate trends and variations, including changes in extremes, and to attribute these changes to global warming, changes in the circulation of the global atmosphere and oceans, and other causes. It also uses integrated historical and proxy data sets to extend the climate record back for 1 000–2 000 years.	CO_2	Research Information	Implemented	Environment Canada, Department of Fisheries and Oceans, Natural Resources Canada
Climate Processes and Earth Observation Program	Program conducts research to improve understanding of energy and water cycles and their component processes, particularly in cold climates. Included are the development and implementation of improved remote sensing and field measurement methodologies. Emphasis is placed on the measurement and modelling of land surface processes and on the evaluation and application of regional climate and weather models as integrating tools.	CO_2	Research Information	Implemented	Environment Canada, Department of Fisheries and Oceans, Natural Resources Canada
The Climate Research Network	Program engages the energies, ideas, and talents of the university community to expand and complement the scientific knowledge and expertise available in the country with respect to climate change and climate variability. It currently consists of a network of nine collaborative research groups in 18 Canadian universities. Each group focuses on a specific area of climate research.	CO_2	Research Education Information	Implemented	Environment Canada
Development of a National Implementation Strategy on Climate Change	A national implementation strategy to meet Canada's obligations under the Kyoto Protocol. Sixteen Issue Tables, involving some 450 experts from multiple perspectives, examined the costs, impacts, and benefits of implementing the Kyoto Protocol and the options open to Canada in developing a climate change strategy. Their work has been	CO_2	Policy Other	Implemented	Government of Canada

Government of Canada (continued)					
	the foundation for the development of the National Implementation Strategy and the First National Business Plan of measures to implement the strategy.				
Eco-Action Funding Program	Provides financial support to non-profit Canadian community-based groups that want to undertake local environmental projects that have measurable, positive impacts on the environment.	CO_2	Fiscal	Implemented	Environment Canada
Education and Awareness Hub Network Pilot	The program establishes a multi-stakeholder climate change public education and outreach hub for effective coordinated local delivery of activities. They are linked and guided at the national level by the Hub Pilot Advisory Team (HPAT). Activities include an electronic clearinghouse for sharing information and best practices, baseline research, and development of indicators.	n.a.	Research Education Information	Implemented	Government of Canada
Environmental Technology Advancement Program	Develops, uses, and transfers Canadian know-how and technologies to help protect and enhance the environment at home and abroad by addressing key environmental issues, such as climate change, clean air, and clean water, while contributing to Canada's sustainable development objectives. The program supports the development and application of scientific support tools, technologies, and know-how to address environmental priorities; partners with other experts and stakeholders to maximize resources in addressing key environmental issues domestically and globally; and enhances private sector capacity to respond to environmental challenges.	CO_2, CH_4, N_2O	Research Technology Transfer	Implemented	Environment Canada
Feasibility of Identifying Heat Effects and Mortality in Canadian Seniors as a Basis for Effective Climate Change Risk Management and Adaptation	The objective of the research is to examine the effects of heat and related mortality rates in Canadian seniors. The data collected will serve as a basis for effective climate change risk management and adaptation capabilities.	CO_2	Research	Implemented	Health Canada

Government of Canada (continued)					
Global Array of Profiling Floats	Argo is an international program that will collect ocean data necessary for understanding and predicting phenomena that influence our global climate, enabling the development of integrated atmospheric and oceanographic models. A global array of 3 000 profiling floats will observe the ocean's upper layer in real time. Canada has committed to the purchase of more than 20 floats today and hopes to commit to 90–150 floats in the overall program.	CO_2	Research Information	Implemented	Fisheries and Oceans Canada, Environment Canada
Global Baseline Surface Radiation Network	Canada participates in an international radiation monitoring network called the Global Baseline Surface Radiation Network. Ground-based measurements are taken continuously using sophisticated equipment. These data are used along with satellite measurements to improve our understanding of how much energy is entering Earth's atmosphere and how much is leaving it. Canadian measurements are taken at Bratt's Lake in Saskatchewan and at the new stratospheric observatory at Eureka in the Canadian Arctic.	CO_2	Research	Implemented	Environment Canada
Greenhouse Gas and Aerosol Measurement Program	The overall objective is to contribute to our understanding of GHGs and aerosols — their trends, budgets, and role in climate change — by carrying out measurements, modelling, and process studies with a Canadian focus and by interfacing with other major international programs. There are currently three major areas of research: GHG and aerosol measurements as part of Canada's contribution to the WMO Global Atmospheric Watch and other international programs; assessment of the role of the Canadian boreal forest and the Hudson Bay lowlands as sources/sinks of GHGs; and assessment of the role of natural and anthropogenic aerosols in Canadian climate change.	CO_2	Information Research	Implemented	Environment Canada
Ice-Core Circum-Arctic Paleoclimate Program	This program is a Canadian-led multilateral program that collects and studies ice cores in order to determine the timing, rate, and cause of past global changes.	CO_2	Research Information	Implemented	Natural Resources Canada
Impact of Climate Change on Migratory Caribou	A program in which herd-specific assessments and other tools are used to evaluate public policy options. This research project is led by Environment Canada's Northern Conservation Division and extends across northern North America.	n.a.	Research	Implemented	Environment Canada

Government of Canada (continued)					
Inter-governmental Panel on Climate Change	Assesses the available scientific information, assesses the potential impacts, and formulates strategies to respond to climate change. Canadian scientists have been lead authors, contributors, and reviewers for the IPCC's First and Second Assessment Reports, produced in 1990 and 1995, respectively. More than 30 Canadian scientists are participating as authors and editors of the IPCC's Third Assessment Report, scheduled for completion in 2001.	CO_2	Research Information Policy	Implemented	Environment Canada, Natural Resources Canada
International Capacity Building	Encourages partnerships with developing countries. These partnerships will help developing countries undertake projects to start reducing their GHG emissions; provide opportunities for business to sell its world-class technology and know-how; secure cost-effective emissions reduction credits; and help level the playing field in the race to meet the growing world demand for climate-friendly goods and services.	CO_2, CH_4, N_2O	Information Technology Transfer	Implemented	Government of Canada
International Geosphere-Biosphere Program	This multilateral program researches, monitors, and assesses biomass burning.	CO_2	Information	Implemented	Natural Resources Canada
International Guidelines for Assessing the Health Impacts of Climate Change	WHO and Health Canada will jointly produce international guidelines for the development of health impacts assessment methodologies in relation to climate change. The guidelines will increase the ability of Canada and other signatory countries of the UNFCCC to assess the health impacts of climate change within their own country by providing methodologies that will enable valid comparisons of impact assessment results and optimum national and international health risk management.	CO_2	Research	Implemented	Health Canada, World Health Organization
Millennium Eco-Communities	Communities initiative brings together resources for those interested in making a difference in their local community by improving the environment. The program shares information in the form of a comprehensive resource on environmental issues, best practices, tools, tips, and networking opportunities.	CO_2	Information	Implemented	Environment Canada

Government of Canada (continued)					
Monitoring Past and Present Climate Change	Collects and analyzes cores from High Arctic and Cordilleran glaciers, contributes to the international body of knowledge that is needed to understand long- and short-term climate change. In addition, research scientists from the Geological Survey of Canada operate a permafrost and active layer monitoring network, supporting the detection and monitoring of climate change in the Arctic. This network contributes to international climate observation programs under the World Meteorological Organization's Global Climate Observing System.	CO_2	Research Information	Implemented	Natural Resources Canada
National Climate Change Secretariat	Manages and supports the national engagement process and the development of Canada's National Implementation Strategy. Assists in ensuring a broad communications link with the public and stakeholders. It is also responsible for consolidating and integrating the work of 16 Issue Tables/Working Groups and from other processes. The Secretariat is a stand-alone body composed of federal and provincial representatives.	CO_2, CH_4, N_2O	Policy Other	Implemented	Government of Canada
National Energy Use Database Initiative	This initiative enables the monitoring and evaluation of progress toward its goal of limiting GHG emissions, provides information to support the development of future initiatives, and ensures the development of a base of expertise in the analysis of energy consumption at the end use level. The development of energy end use data includes reviews of existing data, assessment of information needs, expansion of existing surveys or the creation of new ones to meet these data needs, and the establishment of energy end use data and analysis centres at selected universities.	CO_2	Information Education Research	Implemented	Natural Resources Canada
National Round Table on the Environment and the Economy	An independent agency established by the federal government committed to providing decision makers and opinion leaders with reliable information and objective views on the current state of the debate on the environment and the economy. Serves as a catalyst in identifying, explaining, and promoting the principles and practices of sustainable development. The programs focus on climate change; GHG emissions trading; sustainable development; and health, environment, and the economy.	CO_2	Policy Information Other	Implemented	Government of Canada

Government of Canada (continued)					
Paleo-Reconstruction of Climate	A major Canadian database documenting a wide array of environmental conditions over the past 20 000 years based on information from tree rings, lake and marine sediments, and the fossil record. Those data provide information about ice coverage, sea level, precipitation, wind directions, and permafrost, among other things. Continuing work in partnership with university- and industry-based researchers to add to this database, which provides a look at the long-term climate variability in Canada and the impacts associated with it.	CO_2	Research Information	Implemented	Natural Resources Canada
Pilot Emission Removals, Reductions and Learnings (PERRL) Initiative	PERRL is a federal/provincial/territorial initiative to purchase incremental GHG emissions reductions in strategic areas.	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Fiscal	Approved	Government of Canada
Public Information Program	Through a variety of communication and marketing activities, the Public Information Program increases Canadians' awareness of the environmental impact of energy use and encourages Canadians to adopt energy-efficient practices and to use alternative transportation fuels.	CO_2	Information Education	Implemented	Natural Resources Canada
Remote Sensing Data Sets for Global Climate Modelling	Initiative provides climate-modelling researchers with global data on surface radiation retrieved from satellite measurements and the ability to use these data sets to assess and improve the performance of general circulation models.	CO_2	Research Information	Implemented	Natural Resources Canada
Research and Development for Innovative GHG Reduction Technologies	This initiative will provide funding to support the research, development, and demonstration of 11 separate climate change technology projects by federal departments and research organizations. Projects include oxygen-fired combustion, advance power cycles, microturbines in distributed power systems, CO_2 sequestration in oil sand tailings and gas hydrates, cogeneration from agricultural and municipal wastes, energy efficiency improvements in multi-phase flow, clean combustion of flare gas, gas from biosolids for fuel cells, and power from landfill gas.	CO_2, CH_4, N_2O	Fiscal Research	Implemented	Government of Canada

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Government of Canada (continued)					
Roundtable on Climate Change and Health	Increase the health sector's understanding of the links between air quality and climate change, from a health impacts perspective, and its ability to engage and support climate change health-related actions undertaken by federal department and private sector organizations. It will also identify the role of health professionals, associations, and academics in informing Canadians and encouraging behavioural modification, and in advocating for action to reduce the negative health effects of climate change. The purpose of the project is to support reductions in GHG emissions and to promote and protect the health of the public in the context of climate change.	CO_2	Information	Implemented	Health Canada
Satellite Monitoring of Vegetation	Satellite data are used to develop and demonstrate procedures for monitoring the seasonal development and carbon uptake of vegetation across the Canadian land mass. Vegetation strongly influences regional weather systems, as well as climate. In turn, weather affects vegetation through precipitation and energy regimes. Northern vegetation is a potentially significant carbon sink. Because of rapid seasonal changes (in some areas, the growing season is less than eight weeks) and Canada's size, satellite technology is the only practical means of monitoring the countrywide development of vegetation, which is of considerable economic importance.	CO_2	Information	Implemented	Natural Resources Canada
Strategic Technical Assistance and Responsive Transfer Fund – Pakistan	This project will support the four programming priorities in Pakistan: energy, social sector, environment, and private sector development.	CO_2	Fiscal Information	Implemented	Natural Resources Canada
Sustainable Development Technology Fund (SDTF)	The SDTF provides funds to alliances made up of industry, universities, and research institutes for projects that involve development or demonstration of innovative, sustainable development technologies, in particular climate change solutions.	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Fiscal Technology Development	Implemented	Government of Canada

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Government of Canada (continued)					
Sustainability of Arctic Communities under Climate Change	This project looks at a range of indicators of ecosystem and community sustainability in relation to climate change, oil development, and tourism. Environment Canada carries out caribou research for this project and works on the U.S. National Science Foundation project, which involves three Canadian communities.	CO_2	Research	Implemented	Environment Canada
Urban Environmental Management	This project aims to establish effective and sustainable environmental management educational programs and business services at the Asian Institute of Technology. It also provides opportunities for Canadian environmental companies to demonstrate technologies and services.	CO_2	Information	Implemented	Canadian International Development Agency, Canadian University Consortium, Asian Institute of Technology
World Climate Research Programme	Program furthers scientific understanding of the climate system and climate processes. Within the program, Canadian scientists are working on the World Ocean Circulation Experiment and the Joint Global Ocean Flux Study to help improve understanding of ocean processes and to contribute to the development of ocean components of climate models. Canada is also participating in the Global Energy and Water Experiment by studying hydrological processes in the permafrost-saturated and largely snow-covered lands of the Mackenzie River Basin.	CO_2	Research	Implemented	Environment Canada
Alberta					
Clean Air Strategic Alliance Climate Change Project Team Public Education and Outreach Initiative	The project is being conducted in order to understand the barriers that inhibit Albertans from taking actions to reduce GHG emissions, as well as stimulate behavioural change that will result in reduced GHG emissions. The pilot started in the fall 2000 in four Alberta communities. The pilot program was developed and implemented in industry and government workplaces, community associations, and chambers of commerce throughout Canada. This project builds on current and planned national and provincial outreach programs.	CO_2, CH_4, N_2O	Information Other	Implemented	Alberta Environment
Climate Changes	This program is developing educational resources on global climate change. These will be delivered through professional development workshops to science and social studies teachers in the Destination Conservation network and other education networks across Canada.	CO_2	Education	Implemented	Alberta Environment, FEESA, Destination Conservation

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Alberta (continued)					
Climate Change Central	A public/private partnership to implement the key recommendations of the Alberta Climate Change Round Table. Climate Change Central is a catalyst for governments, municipalities, businesses, institutions, non-governmental organizations, and individuals to focus on climate change strategy, education and capacity building, and technology. Thirteen business and community leaders bring a broad range of expertise to the board of Climate Change Central, which also includes representatives from the environmental and academic communities, municipalities, and industries involved in climate change.	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	Policy Other	Implemented	Alberta Environment
Climate Change Technology Strategy	In 1999, the Government of Alberta and stakeholders completed an Alberta Technology Strategy for the Management of Greenhouse Gas Emissions, which has two main objectives: to ensure the effective deployment of technologies; and to capitalize on global opportunities for exporting climate-friendly technology solutions developed and adapted in Alberta. These objectives are to be accomplished by creating an enabling environment within Alberta, ensuring timely availability of required technologies. Climate Change Central is expected to coordinate implementation of the strategy.	CO_2, N_2O, CH_4	Policy Other	Implemented	Alberta Environment
Destination Conservation (DC) School Retrofit Program	Enrols school jurisdictions in a retrofit program. Students, teachers, and other school staff audit their school's energy consumption and develop plans to reduce consumption through retrofits and lifestyle changes. Students monitor the process. There are currently 973 schools participating in the DC program across Canada.	CO_2	Voluntary Education	Implemented	Alberta Environment
Greenhouse Gas Awareness Project	Project encouraging adoption of energy efficiency. Case studies to highlight leading-edge energy-efficient activities.	CO_2	Information	Implemented	Alberta Food Processors Association

Name of Policy Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
British Columbia					
Assistant Deputy Ministers' (ADMs) Climate Change Committee	The Committee coordinates B.C. government policy development and program initiatives on climate change. The committee includes ADMs from all provincial agencies affected by climate change or climate change policies.	CO_2	Policy Other	Implemented	Government of British Columbia
Canadian Institute for Climate Studies	The Institute does research and development on seasonal climate-prediction products and works with the private and public sectors to apply state-of-the-art understanding of the climate system. Through its management of the Canadian Climate Research Network, the Institute analyzes ongoing climate change and the development of climate models.	CO_2	Research Information	Implemented	Canadian Climate Research Network
Clean Air Day	The B.C. government has proclaimed the Wednesday of Environment Week in June as Clean Air Day. For the past four years, the focus has been climate change. In June 2000, communities across B.C. participated in Clean Air Day events and commuter challenges to promote alternative transportation.	CO_2	Information Other	Implemented	Ministry of Environment, Lands and Parks
Climate Change Public Education and Outreach Initiative	Initiative is working with federal and local governments, industry, and environmental organizations to establish a partnership that will coordinate and facilitate public education and outreach activities in B.C.	CO_2	Voluntary Information	Implemented	Ministry of Environment, Lands and Parks
Environmental Youth Team Program	Provides financial contributions through its Environmental Youth Team program to various agencies to hire youth to participate in environmental protection and education initiatives, including climate change.	CO_2	Fiscal Information Education	Implemented	Ministry of Environment, Lands and Parks
Fiscal Measures	Budget contains measures that will help to reduce GHG emissions. These include a commitment to review opportunities for a revenue-neutral tax shift that will encourage environmentally sound business practices; a partial sales tax rebate for factory-produced, alternative-fuel vehicles; and a future motor fuel tax exemption for ethanol used in gasoline blends, once a commercial-scale ethanol plant is in operation in the province.	CO_2	Policy Fiscal	Implemented	Government of British Columbia

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities
British Columbia (*continued*)					
Green Economy Working Group	A ministerial committee of cabinet that supports B.C. businesses and communities in a transition toward a more sustainable local and global economy. This ministerial committee is overseeing the Green Economy Initiative, which includes the development and implementation of a number of measures that will result in GHG emissions reductions.	CO_2	Policy Other	Implemented	Government of British Columbia
Greenhouse Gas Forum	Comprises representatives of local government, industry, business, labour, environmental groups, and other interests. It advises the Minister of Environment, Lands and Parks and the Minister of Energy and Mines on climate change policy and facilitates the development and implementation of GHG emissions reduction measures.	CO_2	Policy Other	Implemented	Ministry of Environment, Lands and Parks
Greenhouse Gas Mitigation Guidelines under BC's Environmental Assessment Process	Establishing guidelines for GHG mitigation plans for projects reviewed under B.C.'s Environmental Assessment Process. Under the draft guidelines, plans would be submitted and approved as part of the overall project approval.	CO_2	Policy Other	Implemented	Ministry of Environment, Lands and Parks
House in Order Action Plan	Actions under consideration focus on leadership (establish a senior-level champion and secure senior-level commitment; implement an education and awareness program across government; share action plan with local governments); buildings (identify and implement most promising energy efficiency retrofits); electricity (purchase power from new green sources); transportation (reduce emissions related to the government fleet and employee travel); procurement policies (expand the environmental purchasing policy and increase emphasis on low-emission products); waste reduction (expand reduce, reuse, and recycling programs); and monitoring and reporting (establish an annual reporting mechanism).	CO_2	Policy	Planned	Government of British Columbia
Knowledge Network Television Series	Working with Knowledge Network and other partners to produce a climate change television series and a set of half-hour videos.	CO_2	Information Education	Implemented	Ministry of Environment, Lands and Parks

British Columbia (continued)					
Ozone Depleting Substances Legislation	The Ozone Depleting Substances and Other Halocarbons Regulation establishes stricter controls on ozone-depleting substances and includes controls on halocarbons, most of which are potent GHGs.	HFCs	Regulatory	Implemented	Ministry of Environment, Lands and Parks
School Projects	Working with partners to develop a climate change support network for social studies teachers, using climate change as a teaching theme, identifying curriculum linkages, teacher training opportunities, and existing teaching resources.	CO_2	Education	Implemented	Ministry of Environment, Lands and Parks
Scientific Research and Experimental Development Tax Credit	A 10% tax credit for eligible research and development, including for GHG technology.	CO_2	Fiscal	Implemented	Ministry of Finance and Corporate Relations
Urban Areas – Assessment of Options for Reducing Greenhouse Gases in the Greater Vancouver Region	An assessment of options to reduce air pollutants in the Greater Vancouver region is being conducted by the Greater Vancouver Regional District. The work will include an estimate of GHG reductions, reductions of other air contaminants, estimated costs of reduction, and associated benefits, including improvements in air quality and public health impacts. This work has future extensions to assessments for the Lower Fraser Valley and other urban regions.	CO_2	Information Research	Implemented	Ministry of Environment, Lands and Parks
Northwest Territories					
Development of a Strategy to Control Greenhouse Gas Emissions in the Northwest Territories	The initiative will result in the development of a strategy to control GHG emissions. Specific objectives to be accomplished in the strategy include increasing awareness in the NWT of the issue of global climate change and the need to control GHG emissions; engaging all northerners, including government, non-government, industry, and the general public, to take action to control GHG emissions; and identifying and implementing achievable and practical actions that can be undertaken immediately, as well as longer-term actions that will result in future, sustained reductions in GHG emissions in the NWT.	CO_2	Policy Other	Implemented	Government of Northwest Territories

Nova Scotia					
Climate Change Action Pack	Develops and distributes curriculum material on climate change to elementary schools in Nova Scotia. Material has been prepared and tested in workshops with teachers. Teacher kits, complete with lesson plans, curriculum linkages, and materials for classroom use by teachers and students.	CO_2	Education Information	Implemented	Nova Scotia Natural Resources, Environment Canada
Climate Change Human Resources Development Initiative	The goal of this initiative is to develop highly qualified personnel in the areas of climate change and GHG management in the agriculture sector. Work will include research into carbon storage in soils and public education and outreach on climate change to the agriculture sector.	CO_2	Policy Other	Implemented	Nova Scotia Department of Agriculture, Nova Scotia Natural Resources, Agriculture and Agri-Food Canada, Nova Scotia Soils Institute
Climate Change Public Education	Increases public awareness and encourages action on climate change. Various climate change education activities have been implemented, including workshops, videos, brochures, and media materials. A feasibility study has been conducted on the creation of a climate change hub to coordinate and act as a catalyst for action.	CO_2	Information Education	Implemented	Clean Nova Scotia Foundation, Atlantic Coastal Action Program Cape Breton, Nova Scotia Natural Resources, Nova Scotia Environment, Environment Canada, Nova Scotia Power Inc.
Climate Change Strategy	A strategy for the province, including a list of suggested early actions. Consultations with stakeholders were held at six locations in Nova Scotia in November 1999. An Interdepartmental Committee of Climate Change was formed to develop a strategy using the results of the consultation process and other appropriate resources.	CO_2, CH_4, N_2O	Policy Other	Implemented	Nova Scotia Natural Resources, Nova Scotia Environment
Nunavut					
Development of a Strategy to Control GHG Emissions in Nunavut	The purpose of this program is to develop a strategy to control GHG emissions in Nunavut. The process would include a broadly based stakeholder consultation approach to obtain input from residents in order to develop options, priorities, and recommendations for government policy and programs, and also for recommendations from institutes of public government, corporations, business, stakeholders, and the public. The strategy increases awareness in Nunavut of the issue of global climate change and the need to control GHG emissions; encourages all northerners (government, non-government, industry, general public) to	CO_2, CH_4, N_2O	Policy Other	Implemented	Government of Nunavut

Nunavut (continued)					
	voluntarily take strong action to control GHG emissions; identifies and implements achievable and practical actions that can be undertaken immediately, as well as longer-term actions that will result in future, sustained reductions in GHG emissions, taking into consideration the economic, environmental, and social costs and benefits; and identifies economic opportunities that may arise from the use of cleaner, more efficient equipment and technology.				
GHG Emission Forecast for Nunavut 1996–2013	This forecast provides an initial understanding of the current and projected GHG emissions in Nunavut and identifies economic sectors for which further information is required.	n.a.	Research Information	Implemented	Government of Nunavut
Inuit Qaujimajangit (Inuit Knowledge) on Climate Change in Nunavut	The observations within Inuit communities are recorded during semi-directed interviews, workshops, and radio phone-ins. The project is phased to include all of Nunavut over a two-year period.	n.a.	Information Research	Implemented	Government of Nunavut
Ontario					
Pollution Prevention Pledge Program and Pollution Prevention Partnerships	Reports on and recognizes achievements in pollution prevention by individuals, companies, organizations, municipalities, or government.	CO_2	Policy Voluntary	Implemented	Ministry of the Environment
Saskatchewan					
Saskatchewan Stakeholder Advisory Committee on Climate Change	This committee provides a forum for discussion of climate change issues by affected businesses, industry, non-governmental organizations, and government agencies.	CO_2	Policy	Implemented	Government of Saskatchewan

Saskatchewan (continued)					
Climate Change Adaptation Research Network	Examines the probable effects of climate change on the Prairies and develops effective adaptation strategies. Discussions are currently under way between the federal government and the Prairie provinces to determine the feasibility of establishing a network of adaptation researchers for the Prairies, which could serve as a model for the establishment of future adaptation research networks in other regions of Canada. The centre for this network would be in Regina at the University of Regina.	CO_2	Research	Implemented	Government of Saskatchewan
Climate Change and Fragmented Prairie Biodiversity: Prediction and Adaptation	A large number of terrestrial and aquatic species on the highly fragmented prairies are at great risk of extirpation through the effects of climate change. The assumption has been that they will move and that others will take their place. This study will provide models of probable adaptation of selected prairie taxa to climate change and will describe and evaluate possible human responses to those changes in biodiversity.	CO_2	Research	Implemented	Government of Saskatchewan
Yukon					
Climate Change Essay Contest	The Canadian Polar Commission is inviting submissions for an annual climate change essay contest. The contest is open to all students, Grades 9–12, enrolled in Yukon secondary schools. Essays must address the effects of climate change on any aspect of the Yukon environment, such as vegetation, lakes and rivers, wildlife, insects, and humans.	n.a.	Education	Implemented	Government of Yukon
Climate Change Resources for Northern Educators	Information was assembled by a coalition of education and environmental organizations from across the north. This compilation of resources is intended to facilitate an increased awareness and understanding of climate change among students and educators in the Canadian pan-north.	n.a.	Education Information	Implemented	Yukon Economic Development
Community Consultation Program	During the summer of 2000, the Northern Climate ExChange carried out a community tour. This work was funded through the Northern Ecosystems Initiative and involved informal meetings and public information sessions in Yukon communities, including Mayo, Dawson,	n.a.	Education Information	Implemented	Yukon Economic Development

Yukon (continued)					
	Watson Lake, Teslin, Faro, Haines Junction, Beaver Creek, and Burwash Landing. A report and poster are being prepared to summarize the findings of the community tour.				
Energy Awareness Month	This education/awareness campaign is held each year in November. The campaign includes speakers, workshops, and articles in various media.	CO_2	Education Information	Implemented	Yukon Economic Development
Greenhouse Gas Inventory for the Yukon	An inventory of GHGs for the Yukon was completed in 1999. The inventory produced data for 1990 (baseline year), 1995, and 1997–98. Included in the inventory are GHG sources and sinks. The final report on the inventory identifies data gaps and future research priorities and recommends an approach for developing a GHG management strategy.	n.a.	Research	Implemented	Government of Yukon
International Tundra Experiment	The International Tundra Experiment (ITEX) site is in the alpine-tundra ecozone of the Wolf Creek Research Basin. It has been designed to study short- and long-term effects of temperature warming on tundra vegetation biodiversity. ITEX sites are being set up and monitored at various locations in the circumpolar north, and all follow roughly the same protocol. Twenty treatment blocks are divided into five plots. Each block contains one greenhouse plot enclosed with plastic sheeting; one predator ex-closure plot enclosed in chicken wire; one with both the greenhouse and ex-closure treatment together; and one control plot with nothing. Sampling and other procedures are done on only half of each plot to keep some of the vegetation intact.	n.a.	Research	Implemented	Government of Yukon
Northern Climate ExChange	The Northern Climate ExChange serves as a northern entry point into the study of climate change in the circumpolar north. It conducts research and education on the impacts of, and adaptations to, climate change in the north; supports the development of resource-efficient technologies and practices that can contribute to mitigating climate change impacts; and facilitates the exchange of scientific, traditional, and local knowledge, technology, and expertise via a circumpolar "trade route."	CO_2	Research Information	Implemented	Government of Yukon

Yukon (continued)					
Wolf Creek Research Basin	This site is used to monitor climate change, water resources, ecosystem health, biodiversity, and aquatic impacts. It is recognized as an "ecosystem laboratory." One focus of research at this site has been on the energy and water balance processes to assess their sensitivity to climate change. Research at this site was initiated in 1992. Work has been funded by the Indian and Northern Affairs Arctic Environmental Strategy Program and supported by the Environment Canada National Hydrology Research Institute.	n.a.	Research	Implemented	Government of Canada